**RESEARCH PROTOCOLS GHANA -MALI WORKPLANS 2019 – 2020**

**Research protocols Ghana**

**GH1111-19: Cowpea living mulch effect on weed control, soil properties and maize yield**

**Lead: IITA: Dr Abdul Rahman Nurudeen**

1. **Objectives:** To determine the effect of cowpea living mulch on:

* Weed population in a maize-cowpea cropping system
* Maize grain and fodder yields
* Soil properties in a maize-cowpea cropping system

**2. Experimental design and treatments**

Design: Strip plot design

Replications: 4 communities

Treatments:

Living mulch management systems

1. No living mulch
2. Cowpea living mulch same day with maize
3. Cowpea living mulch 1 week after maize
4. Cowpea living mulch 2 weeks after maize

Maize maturity type:

1. Extra-early (Abontem)
2. Early (Omankwa)
3. Medium (Obatanpa)

**3. Field layout**

**Community 1**

|  |  |  |  |
| --- | --- | --- | --- |
| **Extra-early** | **Early** | **Medium** |  |
| **5 m**  **Plot 1** | **Plot 2** | **Plot 3** | **No living mulch** |
| **1m** |  |  |  |
| **Plot 4** | **Plot 5** | **Plot 6** | **Cowpea living mulch + maize same day** |
| **1m** |  |  |  |
| **Plot 7** | **Plot 8** | **Plot 9** | **Cowpea living mulch 1 week after maize** |
| **1m** |  |  |  |
| **Plot 10** | **Plot 11** | **Plot 12** | **Cowpea living mulch 2 weeks after maize** |

**4.5 m**

**15.5 m**

**Community 2**

|  |  |  |  |
| --- | --- | --- | --- |
| **Early** | **Medium** | **Extra-early** |  |
| **5 m**  **Plot 1** | **Plot 2** | **Plot 3** | **Cowpea living mulch 2 weeks after maize** |
| **1m** |  |  |  |
| **Plot 4** | **Plot 5** | **Plot 6** | **Cowpea living mulch 1 week after maize** |
| **1m** |  |  |  |
| **Plot 7** | **Plot 8** | **Plot 9** | **Cowpea living mulch + maize same day** |
| **1m** |  |  |  |
| **Plot 10** | **Plot 11** | **Plot 12** | **No living mulch** |

**15.5 m**

**Community 3**

|  |  |  |  |
| --- | --- | --- | --- |
| **Medium** | **Extra-early** | **Early** |  |
| **5 m**  **Plot 1** | **Plot 2** | **Plot 3** | **Cowpea living mulch 1 week after maize** |
| **1m** |  |  |  |
| **Plot 4** | **Plot 5** | **Plot 6** | **No living mulch** |
| **1m** |  |  |  |
| **Plot 7** | **Plot 8** | **Plot 9** | **Cowpea living mulch 2 weeks after maize** |
| **1m** |  |  |  |
| **Plot 10** | **Plot 11** | **Plot 12**  **4.5 m** | **Cowpea living mulch + maize same day** |

**4.5 m**

**15.5 m**

**Community 4**

|  |  |  |  |
| --- | --- | --- | --- |
| **Early** | **Medium** | **Extra-early** |  |
| **5 m**  **Plot 1** | **Plot 2** | **Plot 3** | **Cowpea living mulch + maize same day** |
| **1m** |  |  |  |
| **Plot 4** | **Plot 5** | **Plot 6** | **Cowpea living mulch 2 weeks after maize** |
| **1m** |  |  |  |
| **Plot 7** | **Plot 8** | **Plot 9** | **No living mulch** |
| **1m** |  |  |  |
| **Plot 10** | **Plot 11** | **Plot 12** | **Cowpea living mulch 1 week after maize** |

**4.5 m**

**15.5 m**

**4. Requirements for field establishment**

* Rows of maize per plot = 6
* Row length = 5 m
* Plot width = 4.5 m
* Spacing between plots = 1 m
* Spacing between rows = 75 cm
* Spacing between Maize plants in a row = 40 cm
* Spacing between cowpea plants within a row = 20 cm
* Rows of cowpea per plot = 5

**5. Land preparation and planting**

Prepare a plot of 23 x 15.5 m2 using the common land preparation method in the region or community. Divide the land into 12 plots as shown in the field lay-out. Sow seed of each crop per plot as stated in the requirements. Sow 3 seeds per hill and later thin to 2 plants per stand at 14 days after sowing. Cowpea should be planted 3 - 4 weeks before planting maize.

**6. Fertilizer application**

Basal fertilizer: Distribute **600 g** of the compound fertilizer (NPK – 15-15-15) per plot evenly among all maize plants at 10 - 14 days after sowing at 5-8 cm from the hills. Ensure the fertilizer application is done within 2 weeks after sowing.

Topdressing: Distribute **200 g** of the sulphate of ammonia per plot evenly among maize early plants in the field at 4-5 weeks after sowing at 5-8 cm from the hills.

**7. Insect pest control**

Spray all legume crops twice with recommended insecticide at flower bud initiation and podding.

**8**. **Weeding**

Ensure twice hand weeding at 3 and 5 weeks after planting or when necessary.

**9. Soil sampling**

Take composite soil samples at a depth of 0 - 15 cm each of the treatment plots after harvest.

**10. Data collection and harvesting**

Data and harvesting should be done on the 2 middle rows of maize and the 2 middle rows of legume in each plot on the following:

1. Soil temperature at vegetative growth (30 days after planting), at 50% tasselling and harvesting
2. Soil moisture at vegetative growth (30 days after planting), 50% tasselling and harvesting
3. Maize plant height at vegetative growth (30 days after planting), 50% tasselling and harvesting
4. Maize grain and Stover yield
5. Cowpea grain and fodder yield
6. Weed species count at harvest
7. Weed biomass

**GH1112-19: Optimizing on-farm nitrogen(N) fertilizer under efficiency under rainfed conditions**

**Lead: IITA: Dr Abdul Rahman Nurudeen; UDS-FA: Dr Williams Attakora; UDS-FA; Dr Adda Wesseh**

1. **Objectives:** To determine the effect of nitrogen fertilizer management on:

* Growth and yield of maize
* Nitrogen use efficiency.
* GHG (N2O-N) emissions

**2. Experimental design and treatments**

Design: Strip plot design

Replications: 4 communities

Treatments:

Control: no fertilizer

Fertilizer type:

1. New blend (15-20-20 NPK + S +Mg +Zn)
2. Compound (23-10-5 NPK + S +Mg +Zn)

Frequency of application:

1. 2 Split (At planting and 5 WAP)
2. 2 Split (At 2 WAP and 5 WAP)
3. 3 Split (At planting, 2WAP and 5WAP)

Organic fertilizer only and with the above combination:

1. Organic fertilizer only (5 t/ha)
2. Organic fertilizer (2.5 t/ha) with fertilizer type and frequency of application
3. **Field layout**

Community 1

|  |  |  |
| --- | --- | --- |
| New blend | Compound |  |
| Plot 1 | Plot 8 | At planting and 5WAP |
| Plot 2 | Plot 9 | At 2WAP and 5WAP |
| Plot 3 | Plot 10 | At planting, 2WAP and 5WAP |
| Plot 4 | Plot 11 | Organic (2.5t/ha), Fert. At planting and 5WAP |
| Plot 5 | Plot 12 | Organic (2.5t/ha), Fert. At 2WAP and 5WAP |
| Plot 6 | Plot 13 | Organic (2.5t/ha), Fert. At planting, 2WAP and 5WAP |
| Plot 7 (Control) | Plot 14 (Organic) | Control and Organic (5t/ha) |

Community 2

|  |  |  |
| --- | --- | --- |
| Compound | New blend |  |
| Plot 8 (Organic) | Plot 1 (Control) | Control and Organic (5t/ha) |
| Plot 9 | Plot 2 | Organic (2.5t/ha), Fert. At planting and 5WAP |
| Plot 10 | Plot 3 | Organic (2.5t/ha), Fert. At planting, 2WAP and 5WAP |
| Plot 11 | Plot 4 | Organic (2.5t/ha), Fert. At 2WAP and 5WAP |
| Plot 12 | Plot 5 | At planting and 5WAP |
| Plot 13 | Plot 6 | At planting, 2WAP and 5WAP |
| Plot 14 | Plot 7 | At 2WAP and 5WAP |

Community 3

|  |  |  |
| --- | --- | --- |
| Compound | New blend |  |
| Plot 8 (Organic) | Plot 1 (Control) | Control and Organic (5t/ha) |
| Plot 9 | Plot 2 | Organic (2.5t/ha), Fert. At 2WAP and 5WAP |
| Plot 10 | Plot 3 | Organic (2.5t/ha), Fert. At planting, 2WAP and 5WAP |
| Plot 11 | Plot 4 | Organic (2.5t/ha), Fert. At planting and 5WAP |
| Plot 12 | Plot 5 | At 2WAP and 5WAP |
| Plot 13 | Plot 6 | At planting, 2WAP and 5WAP |
| Plot 14 | Plot 7 | At planting and 5WAP |

Community 4

|  |  |  |
| --- | --- | --- |
| New blend | Compound |  |
| Plot 1 | Plot 8 | At planting, 2WAP and 5WAP |
| Plot 2 | Plot 9 | At planting and 5WAP |
| Plot 3 | Plot 10 | At 2WAP and 5WAP |
| Plot 4 | Plot 11 | Organic (2.5t/ha), Fert. At planting, 2WAP and 5WAP |
| Plot 5 | Plot 12 | Organic (2.5t/ha), Fert. At planting and 5WAP |
| Plot 6 | Plot 13 | Organic (2.5t/ha), Fert. At 2WAP and 5WAP |
| Plot 7 (Control) | Plot 14 (Organic) | Control and Organic (5t/ha) |

**4. Requirements for field establishment**

* Rows of maize per plot = 8
* Row length = 5 m
* Plot width = 6 m
* Spacing between plots = 1 m
* Spacing between rows = 75 cm
* Spacing between Maize plants in a row = 40 cm

**5. Land preparation and planting**

Prepare a piece of land of 13 x 17 m2 using the common land preparation method in the region or community. Divide the land into 9 plots as shown in the field lay-out. Sow maize seeds at 3 seeds per hill and later thin to 2 plants per stand at 14 days after sowing.

**6. Fertilizer application**

For 2 split fertilizer application: Apply 40 kg/ha N at either planting or 2 weeks after planting and 50 kg/ha N at 5 weeks after planting.

For 3 split fertilizer application: Apply 20 kg/ha N at planting, 20 kg/ha N at 2weeks after planting and 50 kg/ha N at 5 weeks after planting.

The blend and compound fertilizers should be used for the applications at planting and 2 weeks after planting while sulphate of ammonia should be used for the 5 weeks after planting. The fertilizers should be placed at 5-8 cm away from the plants in a hole of 5cm deep and covered.

Manure should also be incorporated into the soil 1 or 2 weeks before planting at 5 t/ha as full rate and 2.5 t/ha as half rate.

**7. Insect pest control**

Spray all legume crops twice with recommended insecticide at flower bud initiation and podding

**8**. **Weeding**

Ensure 2 hand weedings at 3 and 5 weeks after planting or weed when necessary.

**9. Soil sampling**

Take composite soil sample at a depth of 0 - 15 cm across each mulch management system after harvest.

**10. Data collection and harvesting**

Data and harvesting should be done on the 2 middle rows of maize in each plot on the following;

1. Soil moisture at planting, 2, 4, 6, 8 and 10 weeks after planting.
2. Plant height at 14, 24, 34, 44 days after planting and harvest
3. Leaf area index at 14, 24, 34, 44 days after planting and harvest
4. Photo active radiation at 14, 24, 34, 44 days after planting and harvest
5. Root and shoot biomass at 14, 24, 34, 44 days after planting and harvest
6. Grain and Stover yield
7. Nitrogen use efficiency
8. N2O and CO2 emission

**11. Gas sampling (Lead: SARI: Dr Williams Attakora)**

**Chamber measurements of N2O fluxes**

The static chamber technique (Clayton *et al*., 1994[[1]](#footnote-2)) will be used to determine gas fluxes from each plot. For N2O flux measurements, one opaque chamber (0.50 m x 0.25 m x 0.17 m length/width/height) per plot will be fitted onto a collar (0.50 m x 0.25 m x 0.06 m length/width/height), covering an area of 0.125 m2. Collars will be inserted into the soil permanently at a depth of 3 cm, a week after planting in each experimental year. Chambers will be fitted to the collar at the time of gas sampling and will be removed after flux measurements. Four gas samples will be taken during each measurement 0, 20, 40 and 60 minutes after chamber closure, respectively. Each time, a volume of 20 ml will be collected with a syringe through a three-way stop cock, which will be fitted gas-tight to the chamber. The syringe was flushed three times before sampling to mix the chamber air. Samples will be transferred into vials with septum, which will be pre-evacuated down to a vacuum of 0.3 mbar using a vacuum pump. The vials will be transported by express air cargo to the laboratory at Forschungszentrum Jülich, Germany, for analysis. Samples will be analyzed for N2O immediately upon arrival, using a gas chromatograph (Clarus 580, PerkinElmer, Rodgau, Germany), equipped with an electron capture detector (ECD, detection limit: ΔN2O < 1 ppbv). Chamber closure and gas sampling will be conducted between 09:00 and 16:00 h each day of gas sampling. Gas sampling will start two days before fertilizer application daily until three weeks after fertilization. Sampling will then be reduced to two days interval for two weeks and then weekly until the end of the season. Flux rates will be calculated according to the following equations:

where *FN2O* = N2O flux rate (μg N m-2 h-1), *b* = mixing ratio increase (ppb h-1), *VCh* = chamber volume (m3), *MWN2O-N*= molecular weight of N2O–N (28 g mol-1), *ACh* = base area of chamber (m2), *MVcorr* = pressure and temperature-corrected molar volume of air (m3 mol-1).

where *t* = air temperature during measurements (˚C), *p0* = standard atmospheric air pressure (Pa), *p1* = air pressure during measurements (Pa). Annual cumulative N2O fluxes will be calculated by interpolating the N2O fluxes measured between sampling periods (Dong *et al*., 2000)[[2]](#footnote-3).

The emission factor (EF) was estimated as the amount of N2O-N emitted, as a percentage of the fertilizer N applied. The observation-based EF was calculated from individual fertilization treatments in each year and the calculation formula according to (Flechard *et al*., 2007[[3]](#footnote-4)).

where N2Ofert represents the cumulative N2O flux (kg N ha-1 yr-1) in the fertilized plots, N2OzeroN is the cumulative flux in the zero-N treatment, Nfert denotes the amount of applied N (kg N ha-1), k is 0.9 using the Intergovernmental Panel on Climate Change method (IPCC 2001).

**12. Soil physical and chemical analysis**

Particle size analysis will be done on soils sampled before treatment application by the hydrometer method as outlined by Anderson and Ingram (1993). Soil moisture content will be determined gravimetrically by oven drying soil samples at 105 °C until for 24 hours until a constant weight was reached. Organic carbon was determined by the modified Walkley and Black Procedure outlined by Nelson and Sommers (1982). Total N was determined by the Kjeldahl procedure modified to include soil mineral nitrate by the use of salicylic acid to convert all nitrate into ammonium (Tel and Hegatey, 1984[[4]](#footnote-5)).

The exchangeable base cations Ca2+, Mg2+, K+ and Na+ will be extracted with 1.0 M neutral NH4OAc solution (Black, 1965). After extraction, the Ca2+ and Mg2+ contents will be determined using an atomic absorption spectrophotometer (AAnalyst 400, EN 55011-Class A Group 1, Perkin Elmer, Singapore) at wavelengths of 422.7 nm and 285 nm, respectively, and K+ and Na+ by a flame photometer (PFP7, Jenway, Bibby Scientific Ltd, UK) at wavelengths of 766.5 nm and 589 nm, respectively

The Bray 1 extraction solution procedure (Bray and Kurtz, 1945[[5]](#footnote-6)) will be used for measurement of available P. Soil surface temperature will be determined using an infrared thermometer (voltcraft IR 1000-30D, K-Type -50 to 1370 °C, Germany), while soil temperature at 10 cm depth will be measured with a temperature probe (5TE, Decagon devices, USA) inserted 10 cm below the soil surface.

**Effect of maize leaf stripping and stage of growth on fodder quality and growth performance of sheep**

**Lead: UDS-FA: Dr Terry Ansah**

**1. Introduction**

In most communities in northern Ghana, livestock is mostly tethered during the rainy season in order not to damage household farms. Feeding sheep with nutritious forage during this time can be tedious. As opposed to the previous practice of school-going age children herding the sheep, these days children have to go to school. Hence the sheep have to be tethered. Fresh maize leaves are free from any anti-nutritional components and have a crude protein content of 8-10%, higher than the minimum requirement of 6% for effective rumen function. Fresh immature maize strippings have a high level of soluble sugars. This study seeks to determine the digestibility and growth performance maize strippings fed to sheep while being harvested at the silking and tasseling stages of growth.

**2.0. Methodology**

**2.1 Study Area**

The study will be carried out in 4 Africa RISING intervention communities (Cheyohi No. 2, Duko, Tibali and Tingoli) in the Northern Region of Ghana.

**2.2. Growth performance experiment**

Six farmers already working with the Africa RISING project will be selected in each community (Cheyohi No. 2, Duko, Tibali and Tingoli) for the trial. About 5-6 ram-lambs (15.0 ± 2.0 kg) will be selected from each farmer’s pen. These will be offered a weighed amount (2.5% of body weight) of fresh maize strippings harvested at the silking or tasseling stage of growth. The strippings will be offered to tethered sheep on the field. Rams will be offered the strippings and water *ad libitum* twice daily; in the morning (7-8 AM) and the evening (2-3 PM) when the children return from school. Leftovers will be collected and weighed daily to estimate the daily intake whereas the sheep will be weighed at the beginning and biweekly until the end of the study. The third group of farmers (control) will tether their sheep on natural pasture without any maize stripping supplementation. Thus treatment (silking, tasseling and Control) will be replicated twice with the farmer as the replicate and community as a block. Approximately 30 ram-lambs will be required in each community for the study. Data collected include feed intake and growth performance (average daily gain). The protocol for this experiment will be reviewed and by the Research Ethics Committee of the University for Development Studies.

**2.2.1. In situ digestibility experiment and chemical analysis**

Maize strippings will be subsampled weekly and stored in a freezer for subsequent nutrient (CP and fibre analysis) analysis and in situ digestibility.

**2.2.2.1 Chemical analysis**

For chemical analysis, dry matter of fresh strippings will be determined by drying at 60oC for 48 h in a forced-air oven. Organic matter will be determined by ashing samples (1 g) in a muffle furnace at 550oC for 5 h. During chemical analysis, subsamples of the leaf strippings collected and stored weekly will be pooled into biweekly samples and ground through a 1-mm screen before analysis of NDF and ADF using the Van Soest method (Van Soest, 1991[[6]](#footnote-7)). The solution for analysis of neutral detergent fiber (NDF) will include sodium sulfite and α-amylase. Both NDF and ADF values will be expressed inclusive of residual ash.

Crude protein will be determined by the proximate analysis procedure of the AOC (2005) in which CP will be determined by the Kjeldhal procedure and estimated as total N × 6.25.

**2.2.2.2. In situ digestibility**

Subsamples of maize strippings collected and pooled biweekly will be thoroughly mixed and weighed (5 g per bag) into monofilament polyester bags (8 cm10 cm; 51-mm pore size; Sefar America Inc., Depew, NY). Duplicate polyester bags for each sampling time point will be incubated in the rumens of three fistulated sheep for 1, 2, 4, 8, 16, 24, 48 and 72 h. Bags will be placed into a larger mesh retaining sac (3- to 5-mm pore size) to ease retrieval from the sheep. Kinetic parameters of in situ dry matter disappearance (DMD) will be estimated by a non-linear regression procedure of SAS software (SAS Institute, Inc. 1998) using the models of Ørskov and McDonald (1979[[7]](#footnote-8)). The cannulated sheep will be offered a regular forage diet during the digestibility trial. Details of the in-situ procedure have previously been described (Addah *et al*., 2011[[8]](#footnote-9)).

**2.3 Data analysis**

Data obtained from both experiments will be subjected to analysis of variance (ANOVA) using SAS version 9.2. In situ DMD degradability, dry matter intake and growth performance (weight gain, ADG, etc.) of sheep will be analyzed using the PROC MIXED procedure of SAS as a completely randomized design with ram-lamb as the experimental unit in the growth performance, and the cannulated sheep as block and each nylon bag as experiment unit in digestibility study. The initial weight of the sheep will be used as covariate for the analysis of the growth performance data.

Differences in least-square means were declared significant at *P* ≤ 0.05.

**GH1113-19: Assessing the potential for a combination of local Napier grass fodder species and pigeon peas for improved soil health and ruminant productivity in the Guinea savannah zone**

**Lead: UDS-FA: Dr Terry Ansah**

1. **Introduction**

Three out of the six farmers will intercrop Napier grass with pigeon pea *Cajanus cajan* whilst the other three will cultivate sole Napier. An area of 0.25-acre will be cultivated at a distance of 0.5/0.5m between plants. The *Cajanus cajan* will be introduced after every three rows of Napier grass at a planting distance of 1/1m.

The Napier grass will be allowed 4 weeks to establish during which data on plant height, tiller number, stem diameter will be taken. The grass will be harvested, and biomass yield determined. Subsequent harvests will be done at 4 weeks intervals during the rainy season. Two weeks after planting the Napier grass, *Cajanus cajan* will be introduced into the field. Data will be collected on germination, date to flowering, plant height and grain yield. Fodder yield from the *Cajanus cajan* will be estimated. The nutrient composition (DM, CP, NDF, ADF, and Ash) and in vitro digestibility of the harvest fodder in both Napier grass and *Cajanus cajan* will be determined.

1. **Effect of sole Napier or intercrop on the soil:**

Before the planting of the forages, Soil physiochemical properties in the upper 0-15 cm of the soil will be measured specifically soil texture, structure, and porosity. An access tube will be installed in each plot to monitor soil moisture variations while runoff detectors will be installed in block to monitor soil losses. Soil accumulation, soil losses, soil moisture, percentage soil cover will be measured on all plots.

1. **Data analysis*:*** Napier grass and feeding trial

Treatment distribution

|  |  |  |  |
| --- | --- | --- | --- |
| **Blocks** | | | |
| I | II | III | IV |
| Plot 1 (T1) | Plot 4 (T2) | Plot 7 (T3) | Plot 10 (T1) |
| Plot 2 (T2) | Plot 5 (T3) | Plot 8 (T2) | Plot 11 (T3) |
| Plot 3 (T3) | Plot 6 (T1) | Plot 9 (T1) | Plot 12 (T2) |

T1 (Sole Napier), T2 (Napier + *Cajanus*), T3 (Sole *Cajanus*); each plot is 4.5 m x 5 m

Data entry table

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatment** | **Block** | **Rep** | **Biomass yield Napier** | | | | **Biomass yield *Cajanus*** | **Grain yield *Cajanus*** |
| H1 | H2 | H3 | H4 |
| T1 | I | 1 |  |  |  |  |  |  |
| T2 | I | 1 |  |  |  |  |  |  |
| T3 | I | 1 |  |  |  |  |  |  |
| T1 | II | 2 |  |  |  |  |  |  |
| T2 | II | 2 |  |  |  |  |  |  |
| T3 | II | 2 |  |  |  |  |  |  |
| T1 | III | 3 |  |  |  |  |  |  |
| T2 | III | 3 |  |  |  |  |  |  |
| T3 | III | 3 |  |  |  |  |  |  |
| T1 | IV | 4 |  |  |  |  |  |  |
| T2 | IV | 4 |  |  |  |  |  |  |
| T3 | IV | 4 |  |  |  |  |  |  |

H1 (First harvest), H2 (Second harvest), H3 (Third harvest), H4 (Fourth harvest)

**GH1114-19: CCAF’s climate-smart village approach to mainstream climate variability in the promotion and dissemination of climate-smart crop-livestock systems for sustained productivity and reduced risk in Ghana**

**Lead: SARI: Dr Samuel Saaka Buah**

1. **Justification**

Climate is an important determinant of agricultural productivity. Minor changes in climate can have major impacts on agriculture due to its direct dependence on climate and climate-related factors. Warming and declining rainfall generally affect agricultural production negatively. Warm and dry conditions tend to negatively affect soil moisture and nutrients and consequently crop output. Similarly, warm and dry conditions usually impact negatively on livestock production by imposing heat stress, limiting the availability of feed and water, inhibiting growth, reproduction, and milk production as well as facilitating the occurrence of disease. Because of the important role that climate plays in agricultural production, farmers tend to respond to changes in climate by adjusting their practices.

Technologies and practices for climate change adaptation already exist. Adapting to climate change is non-negotiable since future changes in the climate will occur even if full-scale mitigation efforts were to be successfully implemented. Adaptation is particularly important for African farmers who are already facing multiple stresses. Therefore, any intervention that promotes climate change adaptation is critical for improving smallholder resilience and improved socioeconomic outcomes.

1. **Objective and hypothesis**

The objectives of this protocol are to:

* Determine farmers current adaptation responses to climate change highlight gaps or limitations of the current practices
* To engage multi-stakeholders in the agricultural sector in the various communities to take inventory of promising climate-smart crop-livestock-agroforestry practices
* To prioritize the practices for testing in the climate-smart villages through participatory action research.
* Provide up-to-date location-specific climate information and forecast to farmers to inform farm management decisions.
* Train farmers and extension agents on proven climate-smart crop-livestock-agroforestry practices and AR SI technologies that can be used to adapt to the effects of climate change.

1. **Study sites**

This protocol will be implemented in 12 communities otherwise known as climate-smart villages across 3 regions of northern Ghana. The study regions are Northern (Tingoli, Cheyohi no. 2, Doku, Tibali), Upper East (Samboligo, Nyangua, Gia, Bonia), and Upper West (Zanko, Guo, Goli, Goriyiri).

1. **Number of extension staff and farmers to be reached**

About 24 field staff (2 per community) will be trained to improve their knowledge and skills on the causes and impacts of climate change and variability as well as climate-smart agriculture practices. The knowledge acquired will be used to enhance the resilience and adaptive capacity of farmers as indirect beneficiaries.

Training of trainers and working with farmer representatives is the scaling approach that the research team will use to reach out to its target beneficiaries. The team will work directly with about 20 lead farmers (both males and females) in each community which translates to a total of 240 direct representatives. These lead farmers will be sensitized to disseminate any intervention received with their colleagues through peer diffusion of information and technologies. This capacity development will be crucial in promoting awareness of CSA technologies and innovations in Ghana.

1. **Method of data collection**

Qualitative and quantitative approaches will be used to obtain primary and secondary data through a desk review and a socioeconomic survey. The team will undertake an extensive literature search and desk review to identify published farmer climate change adaptation practices, climate data and trends and proven SI technologies. The focus of the review will be on Africa RISING proven SI technologies within the savannah zone of West Africa and northern Ghana in particular. The socio-economic survey, which is intended to among others assess the local need for CSA or SI, will involve fieldwork which involves Focus Group Discussions (FGDs) and individual interviews. Key informant interviews will be conducted using semi-structured questionnaires so that farmers and extension agents will be asked to express their thoughts. Open-ended questions for farmers and extension agents will enable the research team to probe by asking respondents to explain issues. A structured questionnaire will also be administered to the farmers. The questionnaire will capture information on attitudes and opinions on climate change and adaptation. The questionnaire will be pre-tested to determine: the appropriateness of the questionnaire format and wording of questions; appropriateness of verbal translation of questions to illiterate respondents; readiness of trained data collectors for the task and to also allow for revision of the questionnaire if need be. In addition, a simple data collection format will be developed to collect key demographic information on farmers and extension agents that will be trained under the project.

1. **Frequency of measurements**

The frequency of all the data that will be collected will be once. The desk review is a one-off. The socio-economic survey will also be a one-time cross-sectional data collection. Similarly, data on the number of farmers and extension agents trained will be collected at the end of the training session.

1. **Data analysis**

The socio-economic survey or primary data will be collected electronically from the field on tablets and then transferred and analyzed with the aid of the STATA statistical software package. The data will be analyzed using both descriptive statistics and a regression technique. The results will then be presented as tables and graphs for easy visualization.

1. **Link to the data collection template or survey instrument**

Data collection templates are yet to be developed.

1. **Description of the verification demonstrations**

There is dire need to enhance the capacity of both extension service providers and farmers to enable them to choose and combine technologies to develop strategies that will make agricultural production systems climate-smart.

In general, strategies that can make agriculture climate-smart need to be developed and deployed to reduce the vulnerability of this sector. Adopting CSA seems to be a suitable strategy for achieving food security while also mitigating and adapting to climate-related risks. Over the years, several CSA technologies and practices have been developed and promoted in West Africa in general and Northern Ghana in particular, as well as lessons, learnt and challenges with a focus on climate change and variability. Highly valued promising options for climate change adaptation and risk management in West Africa include agroforestry, soil and water conservation technologies (earth bunds, say, tie/contour ridges, conservation agriculture) and climate information services. These technologies have the potential of contributing to the advancement of CSA in Northern Ghana. Currently, climate information is provided by GMET and Esoko at CCAFS climate-village sites in Lawra and Jirapa districts and these could be extended to other project communities. However, information on these promising CSA technologies has not been properly packaged for use as a one-stop source of profiles on technologies. In most cases, these technologies have not been specifically promoted as candidates of CSA, though they have the potential of being used as such

In addition, we need to provide evidence that promising climate-smart crop-livestock practices work through verification demonstrations. Thus, after engaging multi-stakeholders in the various communities to take inventory of promising climate-smart crop-livestock practices, there will be the need to prioritize the practices for testing in the communities known as climate-smart villages through participatory action research. This could be carried out through verification demonstrations. The essence of these demonstrations will be to recommend the combination of climate-smart crop-livestock practices that enhance the adaptive capacity of farmers. For each prioritized CSA practice or technology, two treatments will be used in each verification demonstration. For example, for soil and water conservation demonstration (e.g. tie ridges or earth bund demonstrations), the design of the demonstration and data collection methods are illustrated below.

***Demonstration 1:*** Two treatments will consist of planting maize on the flat or ridges vs. tie ridges. Planting on the flat or ridges, depending on the location represents farmers’ practice (FP). The two treatments will be replicated three times in each site making 6 plots per site (community). Two parallel demonstration plots will be established, one plot will be planted to maize and the other plot will be used for soybean or any grain legume and these two crops will be rotated in the subsequent year.

***Demonstration 2:*** Two treatments will consist of planting maize on the flat or ridges vs. earth bonded flat or ridges. Planting on the flat or ridges without bunds depending on the location represents farmers’ practice (FP). The two treatments will be replicated three times in each site making 6 plots per site (community). Also, two parallel demonstration plots will be established, one plot will be planted to maize and the other plot will be used for soybean or any grain legume and these two crops will be rotated in the subsequent year.

Each plot will measure 10 m x 10 m. Maize will be transplanted in rows at a spacing of 75 cm between the rows and 40 cm between the plants with two plants per stand. While for soybean, row spacing and plant spacing will be 75 cm and 5cm, respectively with one plant per stand. Before land preparation, composite soil samples will be collected from the field for soil chemical analyses. The field will be prepared by ploughing before planting. Recommended fertilizer type and rate will be applied for both test crops at the right time. Insects/disease will be controlled by the application of appropriate insecticide/fungicide. Weeds will be controlled manually using hoes when necessary to prevent weeds from competing with the crops for nutrients and water.

Data on grain yield (kg/ha) and aboveground biomass (kg/ha) will be collected from 5m x 5m quadrant from each plot. Aboveground biomass may be used as livestock feed. The yield and above-ground biomass of maize and soybean or any grain legume will be recorded using a weighing balance. Grain yield, aboveground biomass, rainwater use efficiency will be analyzed using analysis of variance (ANOVA) technique in SAS. Differences among treatment means will be examined for statistical significance using the ‘Least significant difference (LSD) test at 5% significance level. A survey questionnaire will be administered to all participating farmers to document their opinions about the contribution of the technology and its acceptance. A simple cost-benefit analysis of the treatments will be conducted.

**GH1115-19: Identification of varieties of vegetable crop species adapted to the Upper East and Northern Regions of Ghana under dry season conditions.**

**Lead: WorldVeg: Dr Jean-Baptiste Tignegre**

|  |  |  |  |
| --- | --- | --- | --- |
| C. | Objectives: | 1 Evaluate/ demonstrate new promising vegetable varieties (tomato, onion, pepper) for adaptation using farmer’s participatory variety selection  2. Determine vegetable market linkages in the dry season | |
| D. | Experimental Design: | | |
|  | a) No. of replications: | | 4 replicates (Mother trials)  1 replicate (baby trial) |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | b) Proposed design:  1 Mother trials:  1.1 Experimental plot: A raised bed of 1 x 5 m2 will be constructed in all intervention communities for nursing onion, pepper and tomato seedlings. Dressed seeds will be nursed by drilling at a depth of 2-3 cm and mulched. Watering will be done every other day until 3-4 weeks (40 days for onion) after planting when the seedlings are ready for transplanting. Experimental fields in all intervention communities will be ploughed and harrowed.  1.2 Experimental design: In mother trials, Randomized Block Design (RCD) with unit plot size of 5 x 4 m2 will be used.  Treatments: Each experiment will involve 4 treatments (varieties) and four replications.  1.3 Planting date: September 2019  1.4 Cultural practices   * Fertilizer Application:   Basal application of compound fertilizer (NPK, 15-15-15) to both maize and vegetables will be made at rates of 200kg/ha. Topdressing with Sulphate of ammonia (100kg/ha) at 5-6 weeks after planting will follow.   * Weeding: Hand weeding at 2 weeks after planting will be made and 5 weeks after planting. * Insect Pest control: Insect pests will be controlled by the use of Neem oil. * Sites: Lead farms in Niangua, Tekuru (Upper East Region), and Dukuo (Northern Region), and other partner intervention areas.   2. Baby trials (Research in development trials): Technologies tested in baby trials: Each selected farmer will test only one replicate for of 2-3 crop species amongst those in the mother trials. | | | | | | |
|  | CRD | | | SPLIT PLOT | | | |
|  | RBD | | | Others (please specify) | | |  |
|  | c) Treatments: Each variety constitutes a treatment. In the lead farms, each trial will have at least 4 treatments per block, with four blocks in the overall trial. For onions, each block will be allocated six treatments.  List of vegetable varieties (tomato, pepper) proposed for variety trials in Ghana 2019-2020   |  |  |  | | --- | --- | --- | |  | Tomato | Pepper | | 1 | Tropimech | Makohwhem | | 2 | Petomech | Jaune du Burkina | | 3 | UC 82 B | Red Long | | 4 | Local | Local |   Table 2. List of vegetable varieties (WorldVeg onion lines) proposed for variety trials in Ghana in 2019-2020.   |  |  |  | | --- | --- | --- | | N° | Lines | Origin | | 1 | AVON1073 (released) | Worldveg-Mali | | 2 | AVON1074 (released) | Worldveg-Mali | | 3 | AVON1308 | Worldveg-Mali | | 4 | AVON1314 | Worldveg-Mali | | 5 | AVON1310 | Worldveg-Mali | | 6 | AVON1323 | Worldveg-Mali | | 7 | Check (adopted OPV or best local) | Ghana | | | | | | | |
|  | *Single-factor:* | | | | | | |
|  | Factor Description: | | variety | No. of levels: | | tomato: 4 varieties, (onion: 6 varieties | |
|  | *Multi-factor*: | | | | | | |
|  | Factor Description: | | - | No. of levels: | | - | |
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|  |  |  | |  |  | | |
|  | d) Field Trial: | | | | | | |
|  | Total area available (m x m) 1 acre | | | Total no. of plots 12 | | | |
|  | Plot size (m x m) 5 x 4 = 20 m2 | | | Harvest area per plot (m x m) 10 | | | |
|  | e) Non-field Trial: (Describe experimental procedure --- use extra sheets if needed):  At harvest, organoleptic tests will be organized to enable varieties ranking to compare between varieties within same vegetable species | | | | | | |
| D. | Data Collection (List all characters to be measured. Describe sampling/measurement techniques:  Data to be collected on vegetables include plant height at 50% flowering, number of leaves/plant, number of fruits/plot and fruit weight (1st, 2nd and 3rd harvest). Field observations on farmers’ fields and experimental plots will be conducted during the growing season and preliminary identification of diseases will be undertaken based on the symptoms on the plants. In addition, samples will be collected, and the identification and characterization of diseases will be done in the laboratory. For the Zero Energy Cooling Chamber (ZECC) experiment, data on temperature and relative humidity inside ZECC or in ambient conditions, shelf-life, and weight loss, quality parameters (color and total soluble Sugar) will be recorded. Gender preferences and market linkages analysis will be implemented to document farmers’ preference for technologies and profitability of the technology. The use of radio sequences as a communication tool by the Nutrition team in the Northern Region of Ghana for communities’ behavior change will cover vegetable intervention areas. Other data: GPS position of farmland; farmer sex.  Three system intensification domains will be covered by data collection:   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | |  |  |  | | --- | --- | --- | | **Domain** | **Indicator** | **Metric and scale** | | **Indicator** | **Metric and scale** |  |  |  |  | | --- | --- | --- | | 7.1 Production | Crop productivity | Fruit yield (kg/ha/) & fodder yield (kg/ha) at the  field/ plot level | | 7.2 Environmental | - Prevailing diseases | - Disease score at plot level | | 7.3 Social | - Gender preference for varieties | field level (variety rank/sex; rank/age) | | 7.4 Human | - Food quality analysis & nutrients at storage | Quality parameters at plot level (color,  total soluble solids, acidity, vitamin C) |   This sub-activity is integrated into nutrition radio talks, IPM and post-harvest & processing, | | | | | | |
| E. | Proposed Data Analysis:   * Separate trial analysis as RBD with replicate using GenStat program * Over locations and years of trials analysis to determine variety adaptation or stability | | | | | | |
| F. | Comments and Suggestions:   |  |  | | --- | --- | |  | Genetic materials for dry season | | Ghana | Onion (AVON1074, AVON1073, AVON1308, AVON1310, AVON1023, AVON1314, Local); Tomato (AVTO1122, UC82B, Tropimec, Local); Pepper (Nisondia, Makohwhem, Red Long, Local) | | | | | | | |

**GH1116-19: Yield and post-harvest quality of vegetables as affected by improved soil management practices in the dry season in Northern Ghana (Nyangua, Tekuru, Bonia)**

**Lead: WorldVeg: Dr Jean-Baptiste Tignegre**

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| C. | Objectives: | | The objective of this research is to determine the optimum manure use efficiencies and their effects on post-harvest quality of tomato, a high-value crop in Northern Ghana. | | | | | | |
| D. | Experimental Design: | | | | | | | | |
|  | a) No. of replications: | | | | 3 replicates (Mother trials)  1 replicate (baby trial) | | | | |
|  | b) Proposed design:  1 Mother trials:   * 1. Experimental plot:   These investigations will be conducted with the participation of farmers to identify scalable technologies. Two regions in the Upper East and Northern Regions of Ghana in six Lead hubs of Nyangua and Tekuru, Duko, in which, water sources and vegetable growing facilities were built during project phase 1 are targeted to host the trials.  The field layout will be a Randomized Block Design with four replicates. A single tomato variety will be used as planting material for all treatments. Four fertilizer application types will be randomly assigned to the plots listed as below:  T1: Control (no soil amendment)  T2: NPK fertilizer at recommended rate(a)  T3: Manure at recommended rate (5 t/ha)  T4: NPK and manure fertilizer at half the recommended rates.  1.2 Plot sizes: The dimensions for experimental unit plots are 5m x 4m. The area required for each Lead farm will be 20m2/unit plot x 4 manure application rates x 4 reps i.e. 320m2 per Lead farmer.  1.3 Weeding: Hand weeding at 2 weeks after planting will be made and 5 weeks after planting.   * Insect Pest control: Insect pests will be controlled by the use of Neem oil. * Sites: technology parks of Nyangua and Tekuru (Upper East Region), and Dukuo (Northern Region), and other partner intervention areas.   2. Baby trials (Research in development trials): Technologies tested in baby trials: Each selected farmer will test only one replicate of the four treatments. | | | | | | | | |
|  | CRD | | | | | SPLIT PLOT | | | |
|  | RBD | | | | | Others (please specify) | | |  |
|  | c) Treatments: | | | | | | | | |
|  | *Single-factor:* | | | | | | | | |
|  | Factor Description: | | | Variety | | No. of levels: | | 4 | |
|  | *Multi-factor*: | | | | | | | | |
|  | Factor Description: | | |  | | No. of levels: | |  | |
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|  |  |  | | | |  |  | | |
|  | d) Field Trial: | | | | | | | | |
|  | Total area available (m x m) 1 acre | | | | | Total no. of plots 6 | | | |
|  | Plot size (m x m) 5 x 4 = 20 m2 | | | | | Harvest area per plot (m x m) 10 | | | |
|  | e) Non-field Trial: (Describe experimental procedure --- use extra sheets if needed):  At harvest, organoleptic tests will be organized to enable varieties ranking to compare between varieties within same vegetable species | | | | | | | | |
| D. | Data Collection (List all characters to be measured. Describe sampling/measurement techniques:   * soil properties (physical, chemical and biological), soil moisture recorded weekly; nutrient use efficiency; growth and yield: Sowing date; number of plants per plot; days to 50% flowering; number of plants bearing fruits per plot; total number of fruits per plot; WF/p (kg): fruit weight per plot; SM (%): Fruit quality: Fruit size, physical examination of fruits for crack disorder (crack and disease), shelf life, total soluble sugar vitamin C, acidity, pH. Other data: GPS position of farmland; farmer sex.   Three system intensification domains will be covered by data collection:   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | |  |  |  | | --- | --- | --- | | Domain | Indicator | Metric and scale | | Indicator | Metric and scale |      |  |  |  | | --- | --- | --- | | 7.1 Production | Crop productivity at plot and farm level: fruit yield (kg/ha); fodder yield (kg/ha); | Yield (kg/ha/season) at the field/ plot level | | 7.2 Environmental | - Prevailing diseases  - Soil quality analysis | - Disease score at plot level  - Soil chemical quality (NPK, pH,) total  organic matter at farm & plot levels | | 7.3 Human | - Food quality and nutrients analysis at storage | Quality parameters at plot level (color,  total soluble solids, acidity, vitamin C) |   This sub-activity is integrated into nutrition radio talks, IPM, post-harvest & processing interventions,  This sub-activity is linked to sub-activities GH111-1901 | | | | | | | | |
| E. | Proposed Data Analysis:   * Separate trial analysis as RBD with replicate using GenStat program * Over locations and years of trials, analysis to determine variety adaptation or stability | | | | | | | | |
| F. | Comments and Suggestions:   |  |  | | --- | --- | |  | Genetic materials for dry season | | Ghana | Onion (AVON1074, AVON1073, AVON1308, AVON1310, AVON1023, AVON1314, Local); Tomato (AVTO1122, UC82B, Tropimec, Local); Pepper (Nisondia, Makohwhem, Red Long, Local) | | | | | | | | | |

**GH1121-19: Protocol GH112-1901: Efficient feed utilization through improved feed troughs**

**Lead: ILRI: Dr Augustine Ayantunde**

1. **Justification**

Improved feed troughs for small ruminants were designed based on the specifications from Africa RISING Ethiopia and were demonstrated in three communities within northern Ghana namely: Duko and Tibali (Northern region) and Gia (Upper East region) involving thirty farmers (10 farmers in each community) between August 2018 and April 2019. Preliminary results from data collected on the use of the improved feed troughs showed that the improved feed troughs reduced feed waste significantly. The quantity of feed wasted was significantly higher with the use of traditional feed troughs than with the use of the improved feed troughs. The percentage of waste in feeding crop residues using the traditional feed troughs was about 31% compared to less than 1% wastage with the improved feed troughs, which implies about 30% feed saved. The farmers mentioned the drastic reduction in feed waste as the main advantage of improved feed troughs. The results also showed that farmers spent less time feeding the animals with the improved feed troughs; the time spent in feeding the animals was almost halved. The data collection was only conducted in the late dry season and it is necessary to monitor the use of the improved feed troughs across different seasons (wet, early dry and late dry seasons) to have a correct assessment of the benefit of the technology. In addition, the cost of the improved feed trough for small ruminants is currently high at about Ghc1,149 (USD 194). Using the locally available construction materials will significantly reduce the cost of the improved feed trough and will facilitate adoption by the farmers.

1. **Objective and hypothesis**

The objectives of this sub-activity are: (i) To assess the effect of season on feed utilization and manure production using the improved feed troughs in the 2 regions in northern Ghana (Northern and Upper East regions). (ii) To monitor the adoption of the improved feed troughs within and outside the intervention communities. (iii) To evaluate the potential for use of local materials for the construction of the improved feed troughs including cost and benefit analysis. (iv) To assess the effect of additional researcher modifications (feed trough height, shade, storage options and watering points) on overall feed intake, avoided feed wastage and labor savings based on different gender groups. The underlying hypothesis for this sub-activity is that improved feed troughs lead to efficient feed utilization and that seasons affect the quantity of feed that could be saved through improved feed troughs.

1. **Study sites**

This study will be conducted in Duko and Tibali in Northern Region) and in Gia in Upper East Region between August 2019 and March 2020.

1. **Number of farmers to be reached**

Forty-five farmers including the thirty farmers (10 from each community) involved in the demonstration of the use of the improved feed troughs in Duko and Tibali (Northern region) and Gia (Upper East region) will be involved in this study.

1. **Method of data collection**

The participating farmers will be monitored in the wet and early dry seasons over six days consecutively to collect data on feed offered and the leftovers, and time spent feeding the animals using the improved feed troughs compared to the traditional feed troughs. In addition, manure collected from the animals fed using the traditional and improved feed troughs will be measured during the 6 days of the data collection. To assess the potential of reducing the cost of the improved feed troughs, another five farmers will be selected randomly in each intervention community to build feed troughs with local materials. The design of the improved feed troughs with locally available materials will follow the same specifications provided by Africa RISING Ethiopia. Data will also be collected on the use of the feed troughs built with the local materials. Data to be collected will be similar as for the improved feed troughs that had already been constructed. The amount of time spent in looking after the animals while feeding (bringing back dispersed feed, keeping animals to feed comfortably) will be recorded for both improved feed troughs and traditional feeding practices. A survey questionnaire will be administered to all participating farmers to document their opinions about the contribution of the technology and its acceptance. A simple cost-benefit analysis of the improved feed troughs made with local materials will be conducted. Samples of the feed offered, and the left-overs will be analyzed to assess quality for both improved feed troughs and traditional feeding practice. A survey on the adoption of the technology within and outside the intervention communities will be conducted to characterize the adopters and non-adopters, and the drivers of adoption.

1. **Frequency of measurements**

Six days consecutively in wet and early dry seasons.

1. **Data analysis**

Data to be collected will be analyzed with SAS using frequency, means and analysis of variance procedures.

1. **Link to the data collection template or survey instrument**

Not yet available

**GH1211-19: Assessing the buffer and adaptive capacity to harness the resilience of different farm types**

**Lead: WUR: Dr Jeroen Groot**

## **Site description**

The study was conducted in the three Northern regions of Ghana. In each of these three regions low resource endowed (LRE), medium resource endowed (MRE) and high resource endowed (HRE) farms representing the diversity in the villages were researched. The selected communities were intervention communities from Africa RISING; a research for development program led by the International Institute of Tropical Agriculture (IITA) to provide pathways out of hunger and poverty for smallholder households (Africa RISING, n.d.)[[9]](#footnote-10). This research project built onto previous research, so the same communities and the same households have been used in this research project. The researched communities were Duko in the Northern Region (NR), Nyangua in the Upper East (UE) and Zanko in the Upper West (UW). The three Northern regions of Ghana belong to two climatic zones. Duko and Zanko belong to the Guinea savanna and Nyangua belongs to the Sudan savanna (Antwi-Agyei, 2012). Due to these climatic differences, the crops grown and thus consumed differed per region and the challenges faced in malnutrition were different. The regions have been elaborately described by Michalscheck (2019)[[10]](#footnote-11) and the used typology can be found in Table 1.

Table 1. Most important criteria per region to divide the farms into three categories: low resource endowed (LRE), medium resource endowed (MRE) and high resource endowed (HRE). Based on Michalscheck (2019).

|  |  |  |
| --- | --- | --- |
| **Region** | **Farm type** | **Main features per farm type** |
| Northern Region | LRE | 0.8-1.2 hectares. Few poultry. Transport by bicycle. |
|  | MRE | 2 hectares. No cattle. Transport by motorbike. |
|  | HRE | 4-6 hectares. Cattle and many small ruminants. Transport by one or more motorbikes. |
| Upper East | LRE | 0.4 hectares. Some poultry. Transport on foot. |
|  | MRE | 0.8-1.2 hectares. Some poultry and small ruminants. Transport by a bicycle in some cases. |
|  | HRE | 2 or more hectares. Cattle, small ruminants and poultry. Transport by motorbike. |
| Upper West | LRE | 2 hectares. Poultry. Transport by bicycle. |
|  | MRE | Less than 4 hectares. Poultry and small ruminants. Transport by motorbike. |
|  | HRE | More than 4 hectares. Cattle, small ruminants and poultry. Transport by one or more motorbikes. |

## **Choice of disturbances**

Two types of disturbances that could affect the farms have been selected to analyse their impact on nutrition and nutritional resilience of the household: the environmental disturbance *drought* and the economic disturbance *price shock*. Drought during the crop growing season in the region occurs frequently and its impact on food security and malnutrition is high (Saaka *et al*., 2017[[11]](#footnote-12)) as it leads to lower yields for certain crops. Contrastingly, when the production volume of a crop is high leading to a large supply to the market then the price may drop resulting in low profits for the farmers (Amare *et al*., 2018)[[12]](#footnote-13). This socio-economic disturbance is affecting the household differently than the environmental disturbance. A pathway should avoid that nutritional resilience is achieved in terms of the one disturbance but decreased if another disturbance occurs. Per region, it differed what was regarded as a severe drought or a severe price shock. These definitions can be found in Table 2.

Table 2. Definitions of severe drought and severe price shock scenarios in the NR, UE and UW. From Michalscheck et al. (2020, in prep.)

|  |  |  |
| --- | --- | --- |
| **Region** | **Severe drought scenario**  *Yields for drought-affected crops go down but market prices go up* | **Severe price shock scenario**  *Market prices drop due to high availability* |
| NR | 4 weeks of no rainfall during June/July. | -50% in maize market prices  -20% in cassava, millet, rice and yam market prices |
| UE | 2 weeks of no rainfall between July and September | -50% in maize market prices  -20% in cassava, millet, rice and yam market prices |
| UW | 2 weeks of no rainfall in August | -20 per cent in maize market prices |

## **Surveys and focus group discussions**

In each of the three communities, fifteen surveys were executed with men, women and sons with own fields. In every community, respondents were sought to belong to low, medium and high resource endowed households as well as a balance between youth and elderly and male and female respondents. This allowed for analysis if men and women saw nutrition similarly if youth and elderly were equally willing to change their farm and showed the differences between the different levels of resource endowment in terms of initial nutritional situation and adaptation strategies.

The surveys consisted of five parts and started with the *current farm, nutritional and health situation* of a household. Then the respondents were asked about *what affects their nutritional situation, how they would react to disturbances and what those disturbances meant for their nutritional situation* to know how farmers of different resource endowment levels can cope with disturbances. This was followed by a section of their *dreams* regarding the farm and their nutrition. Finally, *options and restrictions* for changing the farm were discussed and the *time path* in which the farmers would see those changes come about. The dreams, options and restrictions and the time path were meant as input for the pathways to make sure they correspond with the farmers’ wishes and possibilities. The complete survey can be found in Appendix 1.

The survey results presented in this report have been tested for statistical significance of differences between means with IBM SPSS Statistics 26.

Additionally, focus group discussions were held in the UE and UW. In the focus groups, we asked participants about the anticipated effects of disturbances on household nutrition and their potential responses. The questions asked were: *How is your nutritional situation affected by a severe drought or severe price shock? What measures do you take when it happens? Which households are more/less affected?* The focus group discussions allowed to hear different opinions at the same time in a conversation rather than a comparison of individual written answers from the surveys afterwards. In the UE one focus group discussion was held with both men and women. In the UW two focus group discussions were held with men and women separately.

## **Expert consultation**

Before the start of executing surveys, Idrissu Baba Mohammed guided the formulation of survey questions towards comprehensible and answerable questions for the farmers to prevent the arising of a distorted picture. Interpretation of the survey results was assisted by two experts. Dr Mahama Saaka, a nutritional expert at the University for Development Sciences, was consulted about the supposed reality of the provided answers by the farmers about amongst others their nutritional situation in a normal year, during a disturbance and after a disturbance. Dr Fred Kizito, chief scientist at the IITA, has done a lot of research in the geographical area and was able to provide some perspective to the dreams of the smallholder farmers as well as their possibilities.

## **Indicators for nutrition**

The indicator used for nutritional diversity of a farm was nutritional functional dispersion (FDis). The more diverse the higher the score. FDis is a concept originating from ecology, taking into account species abundances by a weighted centroid (Laliberté & Legendre, 2010)[[13]](#footnote-14). Instead of species traits in ecology, nutritional FDis uses crops and their characteristics in terms of nutritional composition. The attributes used to calculate the FDis were energy, protein, fat, carbohydrates, fibre, ash, calcium, iron, magnesium, phosphor, potassium, sodium, zinc, copper, vitamin D, thiamine, riboflavin, niacin and vitamin C. The cluster dendrogram in Figure 4, depicting the similarity and dissimilarity of food products based on their nutritional composition, was used as an input for the calculation of FDis.

Apart from diversity, the quantity of food is also important. Therefore, another nutritional indicator for the nutritional situation was the yield of dietary energy expressed in persons adequately fed in dietary energy from the farm (Estrada-Carmona et al., 2020; Timler *et a*l., 2020). Furthermore, the region has a high prevalence of anaemia amongst young mothers and children (Ewusie *et al*., 2014)[[14]](#footnote-15). Saaka *et al*. (2017a)[[15]](#footnote-16) showed that dietary diversity and anaemia are not associated which led to the decision to include iron yield (in persons adequately fed in iron from the farm) as a third nutritional indicator. A farm configuration is considered nutritionally better than the original if all three indicators obtained a higher score.

## **Explorations through the model FarmDESIGN**

In Figure 2 the baseline situation of nine farms covering all three farm types in all three regions are depicted (Baseline\_scenario). For the farms in Duko in the NR Michalscheck et al. (2020, in prep.) scenarios have been modelled how the low, medium and high resource endowed farm react to disturbances in the year of the shock (Shocked\_scenario) and the year after the shock (After\_shocked\_scenario). Two scenarios were developed for the farm situation after the shock: one without and on with the introduction of sustainable intensification practices suggested by the Africa RISING project (AR practices). Insights from the UE and UW served as a regional comparison. The model used was FarmDESIGN, described in Groot *et al*. (2012)[[16]](#footnote-17). Appendix 2a lists for the Northern region the exact modelled scenarios for the LRE, MRE and HRE farms before, during and after a drought or price shock with and without the AR practices. Appendix 2b gives an overview of these sustainable intensification practices and their characteristics.

A screenshot of a cell phone

Description automatically generated

Figure 2. Overview of actual, structural farm and household features at baseline. The maps provide a graphical overview including crops, livestock and distances to fields. Total farm size and cultivated crops are listed. The human icons represent the household composition with red dots marking the male or female household head. Figure from Michalscheck et al. (2018[[17]](#footnote-18)).

Explorations for farm configurations performing better in terms of nutrition started from the After\_shock\_scenario. The model calculates for each farm configuration not only nutritional performance but also operating profit, household leisure time and Euclidean distance. Maximising nutritional performance, operating profit and household leisure time and minimising Euclidean distance were the objectives of the exploration.

Operating profit (OP) is calculated by the gross margin of the crops and the gross margin for animal husbandry subtracted by costs manure, costs for assets, costs for regular labour, costs for casual labour, costs of land and general costs. The formula is given in Equation 1. The calculation behind the subcomponents of this equation can be found in Groot *et al*. (2012)[[18]](#footnote-19).

*Equation 1. The formula of operating profit (OP) where MC is gross margin crops, MA is gross margin animal husbandry, CM is manure costs, CA is assets costs, CR is regular labour costs, CC is casual labour costs, CL is land costs and CG is general costs.*

Household leisure time (TL) is calculated by subtracting the time spent related to agricultural production and the time spent related to off-farm activities from the total time available by the household. The formula can be found in Equation 2 and was earlier described by Ditzler *et al*. (2019)[[19]](#footnote-20).

*Equation 2. The formula of household leisure time (TL) where Tt is total time available by the household, Lfa is time spend doing farm activities and Lof is time spend doing off-farm activities.*

The nutritional information with which FarmDESIGN works are quantifications of dietary adequacy, supply is quantified for dietary energy, carbohydrates, dietary fibre, protein content, fat content, magnesium, manganese, calcium, sodium, iron, zinc, sulphur, copper, vitamin A, vitamin C, thiamine, riboflavin, folate, niacin, vitamin B6, vitamin B12 and vitamin E (Timler *et al*., 2020)[[20]](#footnote-21). The model calculates functional dispersion and dietary energy and iron yield based on an input file with the nutritional composition of all food products produced on the farm. The values of this input file were derived from databases like the FAO West Africa Food Composition Table (FAO, 2012)[[21]](#footnote-22) and the USDA (2019)[[22]](#footnote-23). All values can be found in Appendix 3. Detailed information on the nutritional composition of the AR varieties was not available so they are assumed to be the same as the traditional varieties.

Euclidean distance of the decision variables shows how similar an explored farm configuration is compared to the current. The larger the value for Euclidean distance the more different it is from the current farm a configuration. The calculation of this indicator is given in Equation 2 and 3.

*Equation 3 and 4. The formula of double-scaled Euclidean distance by Barrett (2005)[[23]](#footnote-24) is given in Equation 3. In addition to normalizing the variables values, this formula also rescales the Euclidean distances in a 0-1 range. Where Dpq is the distance of the set of variables of farm pk = (p1, p2, …pn) from the set of variables of the original value qk = (q1, q2, …qn), mdk is the maximum discrepancy for the variable k (Equation 4), and n is the number of variables.*

The explorations included making changes in mostly cropping practices, cropping areas and number of animals raised on the farm and were restricted by the constraints and boundaries of decision variables. Details on the minimum and maximum values for these explorations can be found in Appendix 2a. Other decision variables were inputs, residue use traditional crops, residue use AR crops and the fraction of the feed that went to ruminants and non-ruminants (expressed in the grazing and non-grazing period) period. Constraints were set to make sure the explored farm configurations were realistic for the farmer for example in the amount of land available, in labour requirements and an adequate feed balance for the animals present on the farm.

For each exploration, one thousand configurations were calculated with an amplitude of 0.15 and a probability of 0.85.

General settings for the explorations in FarmDESIGN are found in Table 3.

Table 3. Overview of the objectives, decision variables, constraints, number of solutions and DE settings for the explorations in FarmDESIGN. The grazing period and non-grazing period represent feed balance requirements of ruminants and non-ruminants.

|  |  |  |  |
| --- | --- | --- | --- |
| Objectives | Household leisure time | Maximise |  |
| Operating profit | Maximise |  |
| Nutritional performance:   * Functional Dispersion * Dietary Energy yield * Iron yield | * Maximise * Maximise * Maximise |  |
| Euclidian distance decision variables | Minimise |  |
|  |  |  |  |
| Decision variables | Crop areas | *Dependent per farm* | |
| Number of animals | *Dependent per farm* | |
| Inputs | *Dependent per farm* | |
| Residue use traditional crops | Burning, Animal feed, Green manure | |
| Residue use AR crops | Animal feed, Green manure | |
| Fraction fed non-grazing period | 0 | 1 |
|  |  |  |  |
| Constraints | Farm area total | *Dependent per farm* |  |
| Farm area per farming household member | *Dependent per farm* |  |
| Household leisure time | 0 |  |
| Labour balance | 0 |  |
| Grazing period dev. EDM\* | - | 0 |
| Grazing period dev. TDN\* | -5 | 5 |
| Grazing period dev. CP\* | 0 | 40 |
| Grazing period dev. STR\* | 85 | 1000 |
| Non-grazing period dev. EDM\* | -100 | 0 |
| Non-grazing period dev. TDN\* | -6 | 6 |
| Non-grazing period CP\* | -10 | 30 |
| Non-grazing period STR\* | -65 | 1000 |
|  |  |  |  |
| Number of solutions | 1000 |  |  |
| DE settings | Amplitude: 0.15  Probability: 0.85 |  |  |

\* can depend a bit per farm. The values given reflect the broadest spectra.

## **Pathway identification and calculation of resilience**

Farm configurations that performed better in all three indicators of nutrition as well as in leisure time and operating profit were sought from the After\_shocked\_scenario. All configurations that performed better in terms of all objectives were ranked on their Euclidean distance of the decision variables. Only the Pareto optimal solutions in terms of necessary change per expected nutritional improvement on FDis were plotted in a graph. The graphs for the explorations of the After\_drought\_scenario and the After\_priceshock\_scenario were compared on similarities. A farm configuration that improved nutritional situation both after drought as well as after a price shock can be regarded as the Proposed\_configuration as represented in Figure 3. A pathway to get to that Proposed\_configuration was proposed, based on the farmers’ abilities and wishes. This pathway included recommendations to the farmer what to do in one, three and five years from now to make their farm more nutritionally resilient.

Figure 3 also shows the calculation of initial nutritional resilience and improved nutritional resilience based on the new Proposed\_configuration. To calculate nutritional resilience recovery should be divided by vulnerability to a disturbance. Three values of nutritional resilience were calculated per farm as there were three nutritional indicators. These three indicators could not be integrated into one value because they all represent a different necessary part of a healthy diet.

A close up of a logo

Description automatically generated

Figure 3. Overview of the scenarios modelled in FarmDESIGN and explanation of the calculation of initial nutritional resilience and improved nutritional resilience.

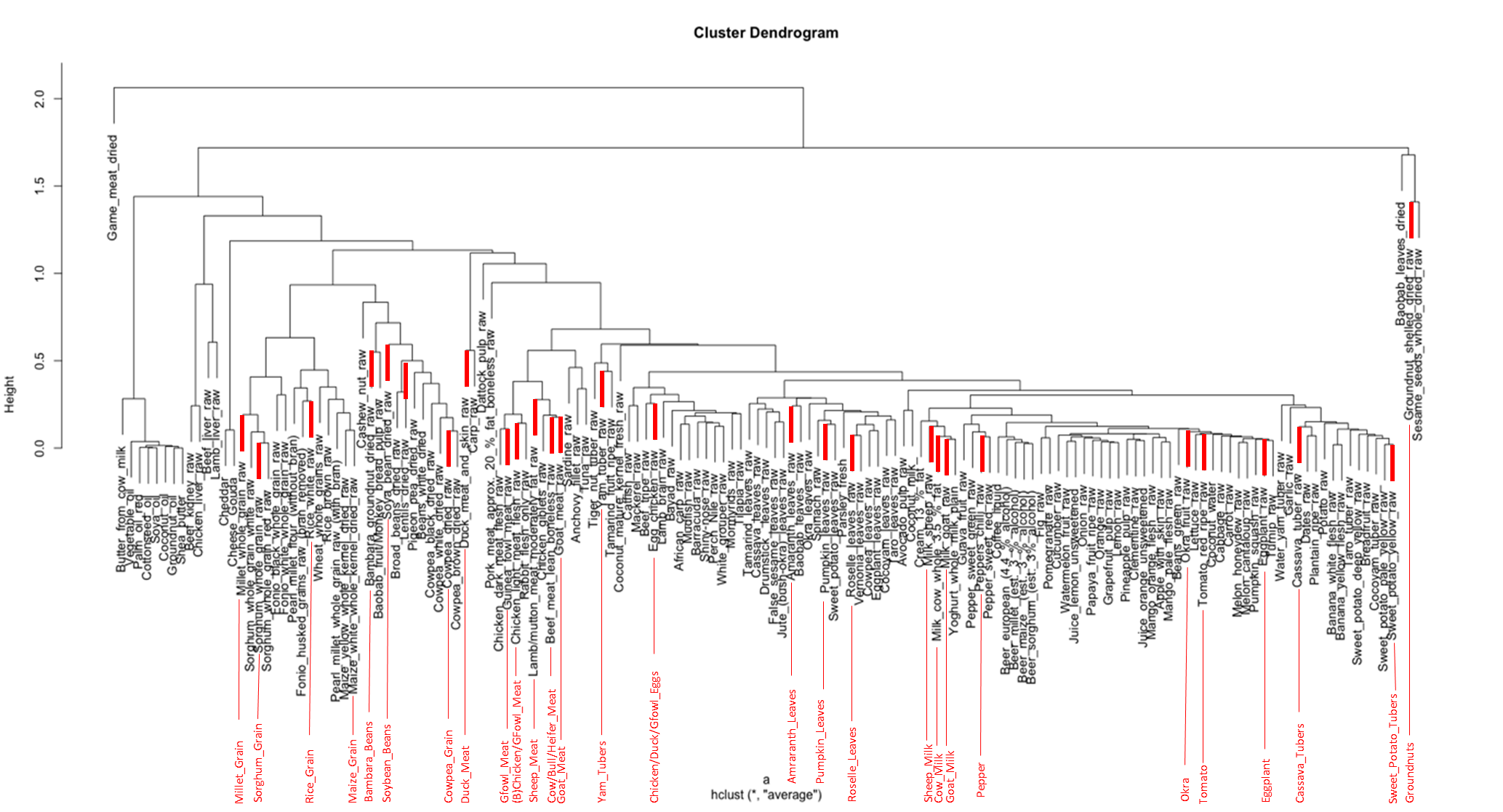


Figure 4. Cluster dendrogram of food products common in West-Africa. The food products from this research project and their location in the dendrogram are reflected in red.

**GH1212-19: Assess the impact of soil-water-conservation interventions on soil moisture and nutrient fluxes**

**Lead: KNUST: Dr Wilson Agyei Agyare**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **ACTIVITY** | **PROTOCOL** | **PERIOD** | **INDICATORS** | **MEANS OF VERIFICATION** | **RESPONSIBLE STAFF** |
| 1 | Carry out SWC refresher training for Bonia and Nyangua farmers | 1. Use A-frames supplied to farmer groups 2. Carry out training in any of the participants’ farms. 3. Group farmers into two groups. 4. Let farmers describe the direction of runoff to the field 5. Assist farmers to demarcate and align the main contour and contour intervals of the farm. 6. Assist farmers determine the soil texture of their farm and expected moisture retention 7. Discuss with them the type of conservation measure suitable for their cropping system. | Aug. 2019 | Number of farmers trained  Crop yield | a. Training report  b. Final project report | Wilson Agyei-Agyare, B.O. Antwi, Fred Kizito |
| 2 | Monitor soil moisture retention and depletion cycle within cropping systems in selected soil and water conservation practices and crop yield | 1. Acquire and install geo-referenced soil moisture and nutrient flux equipment on selected soil and water conservation fields along a catena 2. Determine geo-referenced hydraulic properties on selected SWC fields 3. Take soil samples for NPK analysis 4. Monitor daily soil moisture/ temperature 5. Collect yield data | a, b, c) Aug 2019  d. Cropping cycle | a. No. of installed equipment  b. No. of sites with hydraulic properties determined  c. Student trained  d. Drying cycle of soil  e. soil nutrient depletion  f. Crop productivity | Monitoring report  c. Student thesis  d. Time series of soil moisture/ temp data on SWC plot  e. Report on time series of soil nutrient content  f. Field/Biomass data | Wilson Agyei-Agyare, B.O. Antwi, Fred Kizito, Nurudeen,  +  Other scientists adopting cereal legume experimental plots in Bonia and Nyangua, Northern Region: Duko, Tibali and Chehoy) and Upper West |

The plot representation of the trials is depicted below:

|  |  |  |  |
| --- | --- | --- | --- |
| **Extra-early** | **Early** | **Medium** |  |
| **5 m**  **Plot 1** | **Plot 2** | **Plot 3** | **No living mulch** |
| **1m** |  |  |  |
| **Plot 4** | **Plot 5** | **Plot 6** | **Cowpea living mulch + maize same day** |
| **1m** |  |  |  |
| **Plot 7** | **Plot 8** | **Plot 9** | **Cowpea living mulch 1 week after maize** |
| **1m** |  |  |  |
| **Plot 10** | **Plot 11** | **Plot 12** | **Cowpea living mulch 2 weeks after maize** |

Nutrient lysimeter tubes

Soil moisture diviner access tubes

**GH1221-19: Evaluate the technical and agronomic performance of Bhungroo and solar-energy drip irrigation system in the Upper East region of Ghana.**

**Lead: IWMI: Dr Zenebe Adimassu**

1. **Description of the experiment**

Four irrigation treatments will be used in this field experiment. The four regimes of irrigation include depths of Drip 1 (100 CWR (, Drip 2 (80% CWR), Drip 3 (65% CWR) and farmers’ practice (FP). The four treatments will be replicated three times in each site making 12 plots per site (community).

1. **Study sites**

Each of the study sites has a total land area of 900 m2 for dry-season vegetable production, which is divided into two equal blocks (450 m2), one part will be used for onions and the other part will be used for tomatoes. The spacing between the blocks will be 2 m while the plots in each block will be separated by a distance of 1 m, which serves as a buffer to minimize lateral movement of water from one plot to another. Both the conveyance lines and the driplines have end-caps to flush the system of debris. The driplines will be installed at 30 cm (onion) and 70 cm (tomato) intervals and the driplines have emitters at 20cm spacing and 40 cm spacing for tomato. The drip irrigation systems will be connected to the storage tanks fitted with flow valves to control water flow, water meters measure the amount of water applied and filters remove solid particles from the water being conveyed from the storage tanks to the fields.

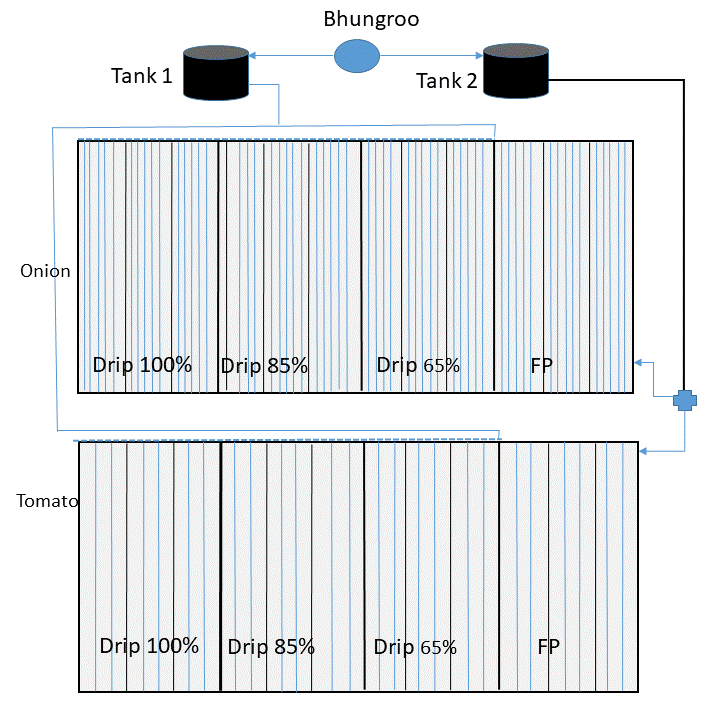


Figure 1. Experimental field layout

Onions and tomatoes will be raised in the nursery and transplanted. Onions will be transplanted in rows at a spacing of 20 cm between the plants and 30 cm between the rows. While for tomato, row spacing and plant spacing will be 70 cm and 40 cm, respectively. The field will be prepared by ploughing to a depth of about 40 cm. Beds will be raised 20 cm above the ground. Recommended fertilizer type and rate will be applied for both test crops. Insects/disease will be controlled by the application of appropriate insecticide/fungicide. Weed control will be done manually using hoes at three-week intervals to prevent weeds from competing with the crops for nutrients and water. Beds will regularly be loosened using hoes to ensure easy penetration of bulbs.

During the crop establishment phase (two to three weeks after transplanting), sufficient water will be applied to all treatments. After the crop establishment phase, the four irrigation application regimes will be implemented. Crop evapotranspiration (ETc) of onion will be computed using eq. 1 and eq. 2 in CROPWAT (ver. 8) model.

Where ETc (mm d-1) iscrop evapotranspiration under standard conditions,ETo (mm d-1)is the reference crop evapotranspiration, Kc is crop coefficient using Allen *et al*. (1998)[[24]](#footnote-25).

Daily Reference Crop Evapotranspiration (ETo) will be computed by using FAO Penman Monteith equation. Although Penman Monteith equation requires several climatic parameters, Penman Monteith in CROPWAT 8.0 can estimate ETo using minimum and maximum temperature using the Hargreaves method given by Hargreaves and Samni (1985)[[25]](#footnote-26):

where *ETo* is the potential evapotranspiration (mmd-1), *Ra* is the extraterrestrial radiation (MJm-2d-1), *Tmax*, *Tmin*, *Tmean*are the maximum, minimum and mean temperatures for a given day, respectively (oC). Accordingly, ETo will be computed from the minimum and maximum temperature in CROPWAT 8.0 using climate data from Navirongo weather station. Irrigation quantity will be is adjusted from ETc using 90% efficiency for drip irrigation.

Irrigation water use-efficiency (IWUI) and crop water use efficiency (WUE) of irrigated onion and will be calculated using eq. 2 and 3 (Sarka *et al*., 2008)[[26]](#footnote-27).

Data on yield and aboveground biomass will be collected from the two central rows of three beds from each replication. The yield and above-ground biomass of onion and tomato will be recorded using a weighing balance. These samples will be converted into kg m-2 and then t ha-1. Yield, aboveground biomass, irrigation water-use efficiency (IWUE) and crop water-use efficiency (CWUE) will be analyzed using analysis of variance (ANOVA) technique in SPSS. Differences among treatment means will be examined for statistical significance using the ‘Least significant difference (LSD) test at 5% significance level.

**GH2121-19: Using the power of radio to promote women’s empowerment for improved nutrition outcomes**

**Lead: UDS-SoH: Dr Mahama Saaka**

1. **Background**

Childhood malnutrition is a global public health problem in many parts of the world including northern Ghana. Potential interventions and strategies are being sought for a lasting solution. One such intervention is the promotion of women’s empowerment as an important entry point for improving nutrition ([Ruel and Alderman, 2013](https://cgiar.sharepoint.com/sites/IITA/Projects/AfricaRising/Shared%20Documents/contracts/WA/UDS-School%20Health-2486/Amendment%205%20IITA-UDS%20PJ-1503%20AG-2486%20(3-9-19).docx#_ENREF_4)[[27]](#footnote-28)). There is evidence of a positive association between women’s empowerment and improved nutrition outcomes of women and for their families ([United Nations, 2007](https://cgiar.sharepoint.com/sites/IITA/Projects/AfricaRising/Shared%20Documents/contracts/WA/UDS-School%20Health-2486/Amendment%205%20IITA-UDS%20PJ-1503%20AG-2486%20(3-9-19).docx#_ENREF_6)[[28]](#footnote-29)) and that education and women’s knowledge of nutrition are key ingredients for a successful women’s empowerment ([Scaling Up Nutrition, 2016](https://cgiar.sharepoint.com/sites/IITA/Projects/AfricaRising/Shared%20Documents/contracts/WA/UDS-School%20Health-2486/Amendment%205%20IITA-UDS%20PJ-1503%20AG-2486%20(3-9-19).docx#_ENREF_5)[[29]](#footnote-30))**.** However, the evidence backing the effect of women’s empowerment in agriculture on malnutrition appears to be context-specific and results are inconsistent and therefore warrants more research.

Women are central actors in achieving better household nutrition ([Nisbett *et al*., 2017](https://cgiar.sharepoint.com/sites/IITA/Projects/AfricaRising/Shared%20Documents/contracts/WA/UDS-School%20Health-2486/Amendment%205%20IITA-UDS%20PJ-1503%20AG-2486%20(3-9-19).docx#_ENREF_3)[[30]](#footnote-31)). Aside from being child bearers and caregivers with a more direct inﬂuence on fetal and infant health, women choose to allocate more resources than men toward their family's health and nutrition([World Bank, 2012](https://cgiar.sharepoint.com/sites/IITA/Projects/AfricaRising/Shared%20Documents/contracts/WA/UDS-School%20Health-2486/Amendment%205%20IITA-UDS%20PJ-1503%20AG-2486%20(3-9-19).docx#_ENREF_8)[[31]](#footnote-32)). However, given persistent gender inequalities in many developing countries, women often lack the autonomy and decision-making power within the household to make key decisions leading to better health and nutritional outcomes ([Cunningham *et al*., 2014](https://cgiar.sharepoint.com/sites/IITA/Projects/AfricaRising/Shared%20Documents/contracts/WA/UDS-School%20Health-2486/Amendment%205%20IITA-UDS%20PJ-1503%20AG-2486%20(3-9-19).docx#_ENREF_1)[[32]](#footnote-33)), and the resources with which to implement those decisions. Therefore, empowering women is increasingly recognized as a proper strategy to improve maternal and child health and nutrition.

This is a continued activity carried over from last year in which we plan to use radio as a tool for providing nutrition, and health messages to empower women in remote or disadvantaged communities of northern Ghana. Empowerment is essentially a transition from a position of enforced powerlessness to one of power (ability to make decisions affecting oneself). One method of achieving women’s empowerment is through mass communication and propaganda. Using radio as a tool of communication is innovative, low-tech, inexpensive and culturally appropriate to citizens of northern Ghana. Community Radio (CR) plays an important role in the lives of women as it creates awareness, provides information and education, improves their skills and on the whole, it promotes social, cultural, political and economic development or empowerment of women ([Yalala Nirmala, 2015](https://cgiar.sharepoint.com/sites/IITA/Projects/AfricaRising/Shared%20Documents/contracts/WA/UDS-School%20Health-2486/Amendment%205%20IITA-UDS%20PJ-1503%20AG-2486%20(3-9-19).docx#_ENREF_10)[[33]](#footnote-34)). Radio has a wide diffusion and usually broadcasts in the local language. As a result of these attributes, it can be used as an effective community outreach campaign tool for women empowerment.

1. **Problem statement**

Childhood malnutrition continues to be a major public health concern in northern Ghana. Potential interventions and strategies are being sought for a lasting solution. One such intervention is the promotion of appropriate infant and young child feeding (IYCF), an activity that mainly lies in the hands of mothers. An essential facilitating factor for addressing poor diets and inadequate food intake is having sound nutrition knowledge. The most important information is what kinds of food to eat and how to prepare the food in the right quantities and mixes and in a way that is safe and clean for children's healthy growth and development. Therefore, empowering women especially mothers with nutrition knowledge and skills has a greater potential to impact positively on household nutrition.

The need for providing nutrition education to a large segment of the population diverse population using effective and efficient strategies cannot be over-emphasized. Mass media, including radio, is one way that this can be achieved but for which evidence is lacking. Scalable interventions are needed to improve infant and young child feeding (IYCF). This intervention study, therefore, seeks to evaluate whether an IYCF nutrition communication strategy using innovative drama series on the radio is associated with positive preventive health-seeking behavior and practices such as exclusive breastfeeding (BF), dietary diversity, and food consistency.

1. **Aim and specific objectives**

The study is to evaluate whether health/nutrition education via innovative radio drama series could improve ma­ternal knowledge and stimulate positive preventive health-seeking behavior and practices. Specifically, the study seeks to:

1. Determine the impact of radio health/nutrition education on the nutritional status of pre-school children.
2. Assess nutrition/health-related knowledge and attitudes
3. Compare the dietary diversity of pre-school children of mothers who listen to radio health/nutrition education and those who do not
4. Assess the level of women empowerment in nutrition
5. **Primary Hypothesis**

We hypothesize that women who are exposed to radio health/nutrition education will demonstrate greater nutrition and health knowledge, positive attitudes towards preventive health practices, and better dietary diversity

1. **Methodology**
2. **Evaluation design**

A two-arm, quasi-experimental, non-randomized, controlled trial pre-post design, will be used to quantify the effectiveness of a **radio listening behavior.** Effectiveness will be measured as a double difference between intervention and comparison groups over time. This quasi-experimental design involves making observations before and after the implementation of the intervention, both in the Intervention Group and Comparison Group.

1. **Study population and sampling**

The study population will comprise mothers with children aged 6-36 months from households participating or not participating in nutrition education on radio across the 25 Africa RISING intervention communities. The sample size will be calculated to detect an effect size of 20 % with 80 % power at 95 % confidence level. At the cluster level, a sample size of 15 households with a male partner/caretaker and children under three years of age will be systematically selected. The comparison and intervention households will be selected from the same clusters and therefore exposed to the same drivers of change such as policies, markets and weather.

1. **The Intervention**

The intervention will consist of a series of health and nutrition drama that is broadcast in local dialects over five radio stations in intervention districts that are largely rural setting. In addition, radio spots that seek to market selected nutrition behavior will be played back seven days per week, up to three times per day for the whole duration of the intervention. The drama series is aired once a week usually in the night (8 p.m. through 10.00 pm). The listening public is invited to phone to ask questions and clarification on issues raised in the drama. A Nutrition Officer is available to respond to such questions. To make the program interesting and participatory, callers who able to answer questions on the topics discussed are compensated with credit for phone calls. The radio jingles/spots focus on promoting the following behaviors:

Behavior 1: Pregnant women need extra food energy and should consume foods rich in nutrients daily for healthy and strong babies

Behavior 2: Start feeding your child with the right food consistency only when the child is six months of age.

Behavior 3: Mothers should feed their children aged 6-24 months, foods that should include animal-source protein (meats, fish, eggs etc.,) and legumes daily.

Behavior 4: Mothers of children 6 – 23 months feed nutrient-rich green leafy vegetables/fruits to their children at least 3 times per week.

Behavior 5: Husbands should provide for all family members including supporting pregnant and lactating women to eat adequate and nutritious meals

Behavior 6: Prepare nutritious balanced diets using the four foods groups (the four star-diet)

Each drama series which were extended version of the radio jingles also promote a unique behavior/practice in a lively and entertaining form that creates room for discussion at the end of the play-back. The drama series is designed ultimately to provide answers to the following questions

1. How can both the man and woman in the household help one another to adequately feed the child?
2. What should be the fathers’ role in ensuring adequate health and nutrition of their family?
3. What role should the community play in supporting families feed themselves?
4. Should men provide the staple and women provide the ingredients?
5. How can women be supported to increase agricultural productivity?
6. Should the best of our farm produce be sold out and for what reasons?
7. Should women be involved in village development committees?
8. Should men take part in childcare such as bathing, feeding, and provision of health care?
9. How best should pregnant women be supported for good outcomes?
10. Making sure the family eats well is solely a woman’s responsibility.
11. Children should sometimes go hungry so that they can learn to do without when they grow older.
12. Because men work hard to provide for the family, they should be given priority at mealtimes.
13. Women should always consult their husbands before going to a health center.
14. Should men take their children to growth monitoring sessions (child weighing)?
15. Infant formula (Bottle feeding) is very good for babies
16. **Data collection**

A structured questionnaire using face to face interviews will be used to collect the required data including socio-demographic, anthropometric measurements, dietary intake and caregiver’s knowledge about food and feeding practices.

Food consumption and dietary diversity of children will be quantified using a 24-hour recall of the child’s consumption, as reported by the caregiver. Household measures (cups, spoons etc.) will be used as visual aids to assist the caregivers in estimating the amount of food the child has consumed. Selection bias will be minimized by applying the same eligibility criteria on the control group as what was used for selecting the intervention group.

1. **Independent and dependent indicators**

The primary independent variable is listening to radio health and nutrition messages (yes versus no) at the time of the survey. Key dependent variables of the study will include; (1) nutrition knowledge score, (2) attitude score, (3) nutritional status of children (4) dietary diversity score**.** A brief description of the study variable measurement is as follows:

1. **Dietary diversity**

Dietary diversity of the women was assessed using the FAO women dietary diversity questionnaire ([FAO, 2016](https://cgiar.sharepoint.com/sites/IITA/Projects/AfricaRising/Shared%20Documents/contracts/WA/UDS-School%20Health-2486/Amendment%205%20IITA-UDS%20PJ-1503%20AG-2486%20(3-9-19).docx#_ENREF_2)[[34]](#footnote-35)). The respondent will be asked to describe the foods she ate or drunk yesterday during the day and night, whether at home or outside the home. The food groups which will be included in the questionnaire are; cereals, white roots, vitamin A-rich vegetables and tubers, dark green leafy vegetables, other vegetables, vitamin A-rich fruits, organs, meat, eggs, fish and seafood, legumes, nuts and seeds, milk and milk products, oils and sweets, spices, condiments, beverages.

Minimum meal frequency is the proportion of children who received complementary foods the minimum recommended number of times in 24-hours. A child was judged to have taken ‘adequate number of meals if he/she received the minimum frequency for appropriate complementary feeding (that is, 2 times for 6–8 months and 3 times for 9-11 months, 3 times for children aged 12 -23 months) in last 24 hours. For non-breast-fed children, the minimum meal frequency was 4.

The WHO defined minimum dietary diversity as the proportion of children aged 6–23 months who received foods from at least four out of seven food groups ([WHO *et al*., 2010](https://cgiar.sharepoint.com/sites/IITA/Projects/AfricaRising/Shared%20Documents/contracts/WA/UDS-School%20Health-2486/Amendment%205%20IITA-UDS%20PJ-1503%20AG-2486%20(3-9-19).docx#_ENREF_7)[[35]](#footnote-36), [World Health Organization, 2007](https://cgiar.sharepoint.com/sites/IITA/Projects/AfricaRising/Shared%20Documents/contracts/WA/UDS-School%20Health-2486/Amendment%205%20IITA-UDS%20PJ-1503%20AG-2486%20(3-9-19).docx#_ENREF_9)[[36]](#footnote-37))**.** The 7 foods groups used for calculation of WHO minimum dietary diversity indicator are:

(i) grains, roots and tubers; (ii) legumes and nuts; (iii) dairy products; (iv) flesh foods; (v) eggs; (vi) vitamin A-rich fruits and vegetables; and (vii) other fruits and vegetables.

1. **Assessment of nutrition-related knowledge and attitudes**

The health and nutrition-related attitudes (HNRAs) will be derived from assessing key behavior/ statements, related to appropriate child feeding, personal hygiene and uptake of health services. They will be measured on a three-point Likert scale (‘agree’, ‘neutral’, ‘disagree’”). A score of 1 is given to responses that disagree, 2 for being neutral and 3 for “agree” yielding a summative altitude score for each respondent. A higher score meant more positive attitude for preventive nutrition/health behavior including appropriate infant and young child feeding practices.

The scores from the items will be summed up to get a total score. Scores of respondents will be categorized as high if total correct responses are ≥ the median score of questions related to health/nutritional attitude, otherwise, it will be regarded as low.

1. **Data analysis plan**

The statistical analyses will be performed using the Statistical Package for the Social Sciences, version 23.0 (SPSS, Chicago, IL, USA). Differences in knowledge (NKS), attitudes (AS) and dietary diversity (DDS) among women who would have listened to the health and nutrition program on the radio at least once per week versus those who will not, will be assessed.

Multivariate linear regression will be used to explore the factors influencing key outcome variables such as health and nutrition-related attitudes (HNRAs) and dietary diversity scores, controlling for potential confounders and imbalances between groups at baseline. Variables with a p value of less than 0.1 in the bivariate analysis will be included in the multivariable regression analysis. Results will be presented as standardized beta coefficients with 95% confidence interval (CI). For all analysis, the significance level was set at 0.05.

The effect of health/nutrition education on the radio will also be assessed using difference-in-difference (DID) estimates. DID is an analytical tool used to estimate treatment effects comparing the pre- and post-treatment differences in the outcome variables of a treatment and a control group. DID is usually implemented as an interaction term between time and treatment group dummy variables in a regression model.

Y= β0 + β1\*[Time] + β2\*[Intervention] + β3\*[Time\*Intervention] + β4\*[Covariates]+ε

**GH2122-19: Improving Child and Maternal Nutrition through Home Container Vegetable Gardening**

**Lead: UDS-SoH: Dr Mahama Saaka**

**1. Background**

Available scientific evidence indicates that exclusive breastfeeding for the first six months of life combined with appropriate complementary feeding could prevent as much as 19 % of all under-five deaths ([Jones *et al.*, 2003](https://cgiar.sharepoint.com/sites/IITA/Projects/AfricaRising/Shared%20Documents/contracts/WA/UDS-School%20Health-2486/Amendment%205%20IITA-UDS%20PJ-1503%20AG-2486%20(3-9-19).docx#_ENREF_5)[[37]](#footnote-38)). To improve these practices, mothers/caregivers and family members need to have sound nutrition information, as well as support to overcome barriers.

Improving complementary feeding through nutrition education (NE) has been identified as a high impact intervention that could reduce stunting and its related burden of disease ([Bhutta *et al*., 2008](https://cgiar.sharepoint.com/sites/IITA/Projects/AfricaRising/Shared%20Documents/contracts/WA/UDS-School%20Health-2486/Amendment%205%20IITA-UDS%20PJ-1503%20AG-2486%20(3-9-19).docx#_ENREF_2)[[38]](#footnote-39)). Therefore, over the years, mothers have been the focus of nutrition education and this has led to a better understanding of nutrition issues among women than their male counterparts. In practice, when it comes to decision making regarding improving optimal feeding of children, the support of men cannot be over-emphasized.

In recent formative research carried out in Northern Ghana to understand the current feeding practices, knowledge, beliefs and attitudes, it came to light that perceived **social acceptability** was a significant and powerful determinant of mothers feeding their children with diversified diets. Non-doers were more likely than doers to mention that lack of support or encouragement from husbands and mothers-in-law to feed their children from **at** least four of these food groups each day was **a barrier.**

Doers were about 2 times more likely than non-Doers to mention "the **husband**" as the person who would approve of feeding their babies foods from at least four of these food groups each day (p-value=0.04 and 15.3 %-point gap)**.**

Having an activity that will encourage husbands to play a major role in supporting their wives in the proper feeding of complementary foods to children 6-24 months of age will, therefore, be an important intervention. This might be a men's support group or a community event that village leaders may hold especially for men with young children.

In Ghana, most community programs seeking to improve the well-being of women and children target mothers and their children with little attention to fathers as key influencers. There is great potential for fathers to make a difference in the rate of the infant feeding practices, but they need the information to make a difference ([Kenosi *et al*., 2011](https://cgiar.sharepoint.com/sites/IITA/Projects/AfricaRising/Shared%20Documents/contracts/WA/UDS-School%20Health-2486/Amendment%205%20IITA-UDS%20PJ-1503%20AG-2486%20(3-9-19).docx#_ENREF_7)[[39]](#footnote-40); [Tohotoa *et al*., 2009](https://cgiar.sharepoint.com/sites/IITA/Projects/AfricaRising/Shared%20Documents/contracts/WA/UDS-School%20Health-2486/Amendment%205%20IITA-UDS%20PJ-1503%20AG-2486%20(3-9-19).docx#_ENREF_14)[[40]](#footnote-41)). Engagement of fathers by educating them on infant and young child nutrition including breastfeeding through men's group activities may greatly improve infant feeding and health behaviors ([Matovu *et al.*, 2008](https://cgiar.sharepoint.com/sites/IITA/Projects/AfricaRising/Shared%20Documents/contracts/WA/UDS-School%20Health-2486/Amendment%205%20IITA-UDS%20PJ-1503%20AG-2486%20(3-9-19).docx#_ENREF_8)[[41]](#footnote-42); [Sloand *et al*., 2009](https://cgiar.sharepoint.com/sites/IITA/Projects/AfricaRising/Shared%20Documents/contracts/WA/UDS-School%20Health-2486/Amendment%205%20IITA-UDS%20PJ-1503%20AG-2486%20(3-9-19).docx#_ENREF_11)[[42]](#footnote-43)) because they play a critical role in providing instrumental and emotional support to mothers and children. Interventions that involve men as agents of positive change are rare in most communities. Engaging fathers is also important because of the significance of both the father-infant relationship (provision of physical and psychosocial support for mothers during the weaning period) and the couple relationship to overall individual and family well-being([Young *et al.,* 2009](https://cgiar.sharepoint.com/sites/IITA/Projects/AfricaRising/Shared%20Documents/contracts/WA/UDS-School%20Health-2486/Amendment%205%20IITA-UDS%20PJ-1503%20AG-2486%20(3-9-19).docx#_ENREF_17)[[43]](#footnote-44)).

Joint decision-making between women and their spouses also significantly increases women’s final decision in the uptake of other maternal health services such as skilled birth attendance which also improves the newborns' nutrition ([Kabakyenga *et al*., 2012](https://cgiar.sharepoint.com/sites/IITA/Projects/AfricaRising/Shared%20Documents/contracts/WA/UDS-School%20Health-2486/Amendment%205%20IITA-UDS%20PJ-1503%20AG-2486%20(3-9-19).docx#_ENREF_6)[[44]](#footnote-45)). In particular, engaging male partners in breastfeeding promotion and education, as well as providing fathers with knowledge and skills for optimal breastfeeding practices, has been shown to positively impact exclusive breastfeeding rates ([Pisacane *et al*., 2005](https://cgiar.sharepoint.com/sites/IITA/Projects/AfricaRising/Shared%20Documents/contracts/WA/UDS-School%20Health-2486/Amendment%205%20IITA-UDS%20PJ-1503%20AG-2486%20(3-9-19).docx#_ENREF_10)[[45]](#footnote-46); [Susin and Giugliani, 2008](https://cgiar.sharepoint.com/sites/IITA/Projects/AfricaRising/Shared%20Documents/contracts/WA/UDS-School%20Health-2486/Amendment%205%20IITA-UDS%20PJ-1503%20AG-2486%20(3-9-19).docx#_ENREF_12)[[46]](#footnote-47)). The extent this applies to appropriate complementary feeding practices has not been documented and therefore merits further investigation.

**2. Problem statement**

In Ghana, most community programs seeking to improve the well-being of women and children target mothers and their children with little attention to fathers as key influencers. There is great potential for fathers to make a difference in the rate of the infant feeding practices, but they need information to make a difference ([Kenosi *et al*., 2011](https://cgiar.sharepoint.com/sites/IITA/Projects/AfricaRising/Shared%20Documents/contracts/WA/UDS-School%20Health-2486/Amendment%205%20IITA-UDS%20PJ-1503%20AG-2486%20(3-9-19).docx#_ENREF_7)19; [Tohotoa *et al*., 2009](https://cgiar.sharepoint.com/sites/IITA/Projects/AfricaRising/Shared%20Documents/contracts/WA/UDS-School%20Health-2486/Amendment%205%20IITA-UDS%20PJ-1503%20AG-2486%20(3-9-19).docx#_ENREF_14)20). Engagement of fathers by educating them on child feeding practices including breastfeeding and men's group discussion on ways to better support their partners to adequately feed their families may greatly improve infant feeding and health behaviors ([Sloand *et al*., 2009](https://cgiar.sharepoint.com/sites/IITA/Projects/AfricaRising/Shared%20Documents/contracts/WA/UDS-School%20Health-2486/Amendment%205%20IITA-UDS%20PJ-1503%20AG-2486%20(3-9-19).docx#_ENREF_11)22) but the evidence is lacking in Ghana and therefore warrants more research in this area.

**3. Aim and specific objectives**

The main aim is to assess whether men engagement in nutrition education at the community levelis effective to improve child feeding practices/ nutrition. The specific objectives are to:

1. Assess whether men would be willing to be engaged in discussing and promoting infant feeding in Northern Ghana
2. Determine the effect of father’s participation in nutrition education sessions on child feeding practices and nutritional status.
3. Determine the effect of father’s participation in nutrition education sessions on the nutritional status of children under three years.

**4. Hypothesis**

The present study will test primarily the hypothesis that father’s participation in nutrition education sessions will improve mothers’ feeding practices and the nutritional status (height-for-age z-score) of children under three years.

**5. Methodology**

**5.1 Evaluation design**

A cluster non-randomized-controlled trial will be used to assess the effectiveness of engaging men in nutrition education on child feeding practices and nutritional status of children. This will entail carrying out pre-post cross-sectional surveys.

**5.2 Sample estimation and study population**

The sample size will be calculated that is considered adequate with 80 % power to detect an effect size of 20 % at 95 % confidence level.

Households with men participating in community nutrition education activities will constitute the intervention group whilst the comparison group will comprise households not involving men in such activities. At the cluster level, a sample size of 15 households with a male partner/caretaker and children under three years of age will be systematically selected across the 25 Africa RISING intervention communities.

**5.3 The Intervention**

Men’s support group will be formed and equipped with the necessary knowledge and skills to take advocacy and promotional role in ensuring adequate nutrition of families. Nutrition education sessions will be held at least once a month, and community durbars and special fathers’ days at local health centers/clinics will be held once every quarter for 12 months.

Promoting healthy behaviors and healthcare-seeking through peer-group education among men is hypothesized to improve knowledge, motivation and social support for these behaviors and, in turn, lead to better household practices around diet, health, and hygiene, and ultimately better maternal and child nutrition outcomes.

Community health workers including nutritionists within the Ghana Health Service will provide supportive supervision and monitoring of the men’s dialogue group activities.

The focus areas during the men’s group nutrition education sessions which will be held at least once a month are:

1. Infant and young child feeding (timely breastfeeding, exclusive breastfeeding, continued breastfeeding up to two years and appropriate complementary feeding practices).
2. Feeding on diversified diets
3. Maintaining good sanitation and hygiene at personal and household levels
4. Nutrition and maternal care in pregnancy (importance of proper nutrition with the available resources and the importance of attending antenatal clinics).
5. Discuss ways to better support their partners to adequately feed their families and develop action plans to integrate infant feeding content into their current activities with their group and community members:
6. Encouraging men to take part in decision-making regarding exclusive breastfeeding, time to start complementary feeding, what food for start of complementary feeding, and order of serving food during mealtimes.
7. Providing physical support to the lactating mother: assisting the mother with household chores, assisting the mother with farming activities, accompanying mother for child health clinics, and allowing other family members/relatives to support the mother after delivery.
8. Providing psychological support to the lactating mother: providing appropriate information on breastfeeding to the mother.
9. Providing financial support: buying food for the child, buying food for the lactating mother, and transporting to the child health clinics.
10. Promoting optimal child feeding practices: providing information about young child feeding.

**5.4 Data collection**

Data collection will be carried out through household interviews using a pre-tested structured questionnaire. Assessment will include anthropometric measurements (height-for-age, weight-for-height, and weight-for-age), interviews on socio-economic status, dietary intake and caregiver’s knowledge about food and feeding practices.

**5.5 Independent and dependent study variables**

The primary independent factor, male involvement in infant and young child nutrition education that will be defined using 14 main explanatory variables presented in five dimensions ([Thuita *et al*., 2015](https://cgiar.sharepoint.com/sites/IITA/Projects/AfricaRising/Shared%20Documents/contracts/WA/UDS-School%20Health-2486/Amendment%205%20IITA-UDS%20PJ-1503%20AG-2486%20(3-9-19).docx#_ENREF_13)[[47]](#footnote-48)). These five dimensions are:

* Decision-making in infant and young child feeding will be quantified in terms of whether or not the male is involved in taking the final decision on exclusive breastfeeding, time to start complementary feeding, what food for start of complementary feeding, and order of serving food during mealtimes.
* Providing physical support to the lactating mother as follows: feeding the child during mealtimes, assisting the mother with household chores, assisting the mother with farming activities, accompanying mother for child health clinics, and allowing other family members/relatives to support the mother after delivery.
* Providing psychological support to the lactating mother will be assessed in terms of providing appropriate information on breastfeeding to the mother.
* Providing financial support will be assessed as follows: buying food for the child, buying food for the lactating mother, and transporting to the child health clinics.
* Promoting optimal child feeding practices are as follows: providing information about young child feeding.

The main explanatory variable, male involvement, will be assigned binary responses, (“1” (yes) representing the fact that male partner/caretaker plays a role and “0” (no) representing the fact that male partner/caretaker does not play a role). Level of male involvement will be measured using individual male involvement explanatory variables and using an ad hoc male involvement index with all variables equally scored with 1 (yes) and 0 (no). The overall score will be categorized as low male involvement (scores 0–7) and a high level of male involvement (scores 8–14).

The main outcome measure will be child nutritional status (stunting, wasting, and underweight, measured by height-for-age, weight-for-height, and weight-for-age indices less than −2 SD respectively). A brief description of how the study variables will be measured is as follows:

Food intake will be assessed using a semi-quantitative method based on recall of foods consumed by the household during the 24 hours preceding of the survey from the household member who prepared the previous day’s meals.

Food security will be assessed by applying the Household Hunger Scale (HHS) ([Ballard *et al.*, 2011](https://cgiar.sharepoint.com/sites/IITA/Projects/AfricaRising/Shared%20Documents/contracts/WA/UDS-School%20Health-2486/Amendment%205%20IITA-UDS%20PJ-1503%20AG-2486%20(3-9-19).docx#_ENREF_1)[[48]](#footnote-49)) and Household Food Insecurity Access Scale (HFIAS) ([Coates *et al*., 2007](https://cgiar.sharepoint.com/sites/IITA/Projects/AfricaRising/Shared%20Documents/contracts/WA/UDS-School%20Health-2486/Amendment%205%20IITA-UDS%20PJ-1503%20AG-2486%20(3-9-19).docx#_ENREF_3)[[49]](#footnote-50)).

Dietary diversity score (DDS) will be calculated based on a total of seven different food groups according to WHO specifications: (1) grains, roots and tubers, (2) legumes and nuts, (3) dairy products, (4) flesh foods, (5) eggs, (6) vitamin A rich fruit and vegetables, (7) other fruit and vegetables.

Weight will be measured using standardized digital flat scales (Seca 874, capacity: 200 kg, SECA GmbH & Co KG, Hamburg, Germany) with tara function. Height/length will be taken from children using infantometer measuring boards. Heights and weights will be assessed to the nearest 0.5 cm and 0.1 kg, respectively.

**5.6 Training of Men’s Groups**

During the training, male leaders will explore gender norms around infant feeding and caregiving practices, learn about the importance of exclusive breastfeeding and appropriate complementary feeding, discuss ways to better support their partners to adequately feed their families, and develop action plans to integrate infant feeding content into their current activities with their group and community members. These learning activities hopefully will encourage men to view infant feeding as a family issue, and not solely a woman’s issue.

**6. Data analysis**

SPSS version 22.0. ([IBM Corp., 2011](https://cgiar.sharepoint.com/sites/IITA/Projects/AfricaRising/Shared%20Documents/contracts/WA/UDS-School%20Health-2486/Amendment%205%20IITA-UDS%20PJ-1503%20AG-2486%20(3-9-19).docx#_ENREF_4)[[50]](#footnote-51)) will be used for data analysis. Anthropometric data will be converted to z-scores using WHO Anthro Plus (version 3.2.2, January 2011).

The WHO infant and young child feeding (IYCF) indicators MDD, MMF as well as MAD will be calculated according to WHO guidelines ([World Health Organization, 2008](https://cgiar.sharepoint.com/sites/IITA/Projects/AfricaRising/Shared%20Documents/contracts/WA/UDS-School%20Health-2486/Amendment%205%20IITA-UDS%20PJ-1503%20AG-2486%20(3-9-19).docx#_ENREF_15)[[51]](#footnote-52)), height-for-age z-scores (HAZ), weight-for-age z-scores (WAZ), and weight-for-height z-scores (WHZ) will be generated as per the most recent WHO growth standards ([World Health Organization, 2006](https://cgiar.sharepoint.com/sites/IITA/Projects/AfricaRising/Shared%20Documents/contracts/WA/UDS-School%20Health-2486/Amendment%205%20IITA-UDS%20PJ-1503%20AG-2486%20(3-9-19).docx#_ENREF_16)[[52]](#footnote-53)). Differences in socio-demographic characteristics and food groups consumed between intervention and control groups will be tested using the t-test for continuous variables, χ2 test for nominal variables, and Mann-Whitney test for ordinal variables. A difference-in-differences analysis will be used to calculate intervention effects. Within the difference-in-differences (DiD) framework, HAZ, DDS and binary outcomes (MDD, MMF, MAD) will further be analyzed using linear probability models ([Mood, 2010](https://cgiar.sharepoint.com/sites/IITA/Projects/AfricaRising/Shared%20Documents/contracts/WA/UDS-School%20Health-2486/Amendment%205%20IITA-UDS%20PJ-1503%20AG-2486%20(3-9-19).docx#_ENREF_9)[[53]](#footnote-54)). Adjusted odds ratios (AORs) and 95% confidence intervals (95% CI) of associated factors with the key outcome measures will also be estimated.

**GH2123-19: Engaging Men to Increase Support for Optimal Child Feeding Practices Using Care Group Approach/Model**

**Lead: UDS-SoH: Dr Mahama Saaka**

**1. Background**

In most households of Northern Ghana, there is an inadequate intake of micro-nutrients partly due to lack of access to a variety of foods, and intake of animal source foods is low. The quality of a child’s diet is a key determinant of optimal growth, development and health. Poor nutrition not only retards growth and development but also increases children’s risk of developing chronic diseases such as obesity, increased cholesterol levels and hypertension later in life ([Berenson *et al*., 1998](https://cgiar.sharepoint.com/sites/IITA/Projects/AfricaRising/Shared%20Documents/contracts/WA/UDS-School%20Health-2486/Amendment%205%20IITA-UDS%20PJ-1503%20AG-2486%20(3-9-19).docx#_ENREF_1)[[54]](#footnote-55); [Schneider *et al*., 2007](https://cgiar.sharepoint.com/sites/IITA/Projects/AfricaRising/Shared%20Documents/contracts/WA/UDS-School%20Health-2486/Amendment%205%20IITA-UDS%20PJ-1503%20AG-2486%20(3-9-19).docx#_ENREF_6)[[55]](#footnote-56); [Skinner *et al*., 2004](https://cgiar.sharepoint.com/sites/IITA/Projects/AfricaRising/Shared%20Documents/contracts/WA/UDS-School%20Health-2486/Amendment%205%20IITA-UDS%20PJ-1503%20AG-2486%20(3-9-19).docx#_ENREF_8)[[56]](#footnote-57)).

Micronutrient deficiencies may be addressed by increasing the availability of, access to, and ultimately consumption of foods that are rich sources of micronutrients. A food-based approach that could help reduce micronutrient deficiencies by providing nutrient-rich foods is home gardening ([Berti *et al*., 2004](https://cgiar.sharepoint.com/sites/IITA/Projects/AfricaRising/Shared%20Documents/contracts/WA/UDS-School%20Health-2486/Amendment%205%20IITA-UDS%20PJ-1503%20AG-2486%20(3-9-19).docx#_ENREF_2)[[57]](#footnote-58); [Holmer, 2011](https://cgiar.sharepoint.com/sites/IITA/Projects/AfricaRising/Shared%20Documents/contracts/WA/UDS-School%20Health-2486/Amendment%205%20IITA-UDS%20PJ-1503%20AG-2486%20(3-9-19).docx#_ENREF_3)[[58]](#footnote-59); [Keatinge *et al*., 2011](https://cgiar.sharepoint.com/sites/IITA/Projects/AfricaRising/Shared%20Documents/contracts/WA/UDS-School%20Health-2486/Amendment%205%20IITA-UDS%20PJ-1503%20AG-2486%20(3-9-19).docx#_ENREF_4)[[59]](#footnote-60); [Shisanya and Hendriks, 2011](https://cgiar.sharepoint.com/sites/IITA/Projects/AfricaRising/Shared%20Documents/contracts/WA/UDS-School%20Health-2486/Amendment%205%20IITA-UDS%20PJ-1503%20AG-2486%20(3-9-19).docx#_ENREF_7)[[60]](#footnote-61)). It is further argued that vegetable gardening enables women to have greater authority over the quality of the family diet ([Ruel and Levin, 2001](https://cgiar.sharepoint.com/sites/IITA/Projects/AfricaRising/Shared%20Documents/contracts/WA/UDS-School%20Health-2486/Amendment%205%20IITA-UDS%20PJ-1503%20AG-2486%20(3-9-19).docx#_ENREF_5)[[61]](#footnote-62)). In addition, the potential use of household wastewater for irrigation and household organic wastes for compost provides opportunities to make efficient use of limited resources and close broken nutrient cycles and this is of benefit to the environment and can represent a sustainable system.

Analysis of the data collected in recent formative research in the Upper East Region of Ghana showed that the only determinant of fruit and vegetable consumption was perceived self-efficacy. Families that consumed vegetables were 2.93 times more likely than non-consumers to mention “ the availability and/or own production of fruits and vegetables " as a factor that makes it easier for one to consume fruit and vegetablesat least 3 times per week OR = 2.93 (p =0.01 and 25.0 % point gap)**.** The programme implication of this finding is that home gardens may contribute to improving the availability of vitamin-rich fruits and vegetables. However, poor diets and inadequate food intake are not always the result of a lack of food or money to buy food. People must have some knowledge of nutrition: the most important information is what kinds of food to eat and how to prepare the food in the right quantities and mixes and in a way that is safe and clean for children's healthy growth and development. Therefore, concurrent nutrition education and homestead vegetable production have a greater potential to impact positively on household nutrition.

**2. Problem statement**

In most households of Northern Ghana, there is an inadequate intake of micro-nutrients partly due to lack of access to a variety of foods, and intake of animal source foods is low. Micronutrient deficiencies may be addressed by increasing the availability of, access to, and ultimately consumption of foods that are rich sources of micronutrients. For poor households, vegetables and fruits are often the only sources of micronutrients in the family diet. A home garden can supply a family with substantial quantities of a variety of foods all year round and a source of family income. Home gardening, therefore, has economic and nutritional merit but which most households are not taking advantage of due to some constraints including lack land space and water availability. Therefore, this study seeks to evaluate whether home container gardening would be a good means to improve household food and nutrition security.

**3. Aim and specific objectives**

The main aim is to establish home container vegetable gardens and evaluate their contribution to food and nutrition security among rural households. The specific objectives are to:

1. Determine the impact of home gardens on the nutritional status of pre-school children.
2. Assess access to food at the household level.
3. Compare dietary diversity of pre-school children in households engaged in home gardening and those not.

**4. Hypothesis**

The study will test the hypothesis that families participating in home gardening activities have better food security and feed on a more diversified diet than families without.

**5. Evaluation design**

A quasi-experimental design will be used, comparing pre- and post-intervention data for a group of intervention households that received training and support in home gardening, and a group of comparison households that will not receive training or support. Nutritional status and dietary intake of children aged 6-59 months from the study groups will be compared.

**6. Study population and sampling**

The study population will comprise children aged 6-59 months from households participating or not participating in home container gardening across the 25 Africa RISING intervention communities. The sample size will be calculated to detect an effect size of 20 % with 80 % power at 95 % confidence level. At the cluster level, a sample size of 15 households with a male partner/caretaker and children under three years of age will be systematically selected. The comparison and intervention households will be selected from the same clusters and therefore exposed to the same drivers of change such as policies, markets and weather

**7. The Intervention**

The intervention focuses on introducing improved (open-pollinated) nutrient-rich vegetable varieties suitable for growing in a home garden and for which seed is locally available. **Increased vegetable consumption through awareness campaigns** that stress the relationship between diet and health is also a key component of the intervention. Vegetables that will be promoted will include eggplants, beans and pulses, leafy vegetables and other vegetables (e.g. okra, tomato).

The project aims to: increase the awareness that people can grow nutritious vegetable in home gardens with little money; increase the ability to access at least two nutritious vegetable and fruit year-round; increase the skill to prepare balanced diet with locally available foods.

The following intervention activities will be carried out:

1. Identify the most commonly grown vegetables and main cropping patterns in the area.
2. Work with demonstration home garden managers to demonstrate how best to intensify and diversify the home garden crops grown.
3. A field agricultural worker will help families to analyze the main problems that exist in their home gardens.
4. Conduct demonstrations involving techniques for setting up container gardening.
5. Organize and conduct demonstration tours and exchange visits among home garden managers or owners to show improvements and enable people to learn from each other which home garden management practices are feasible.
6. Home garden owners or managers (e.g. husband or wife or both) will be invited to a series of training sessions, involving demonstrations of good home garden practices and an introduction to new techniques.
7. Home garden owners or managers will then, with the help of the fieldworker, develop plans for improvement of their home gardens.

**8. Data collection**

Demographic, socio-economic and home garden information will be collected during household interviews using a structured questionnaire. Other assessments will include anthropometric measurements, dietary intake and caregiver’s knowledge about food and feeding practices.

Household food security will be assessed by measuring food consumption score (FCS) and individual and household dietary diversity. Food consumption and dietary diversity of children will be quantified using a 24-hour recall of the child’s consumption, as reported by the caregiver. Household measures (cups, spoons etc.) will be used as visual aids to assist the caregivers in estimating the amount of food the child has consumed. Selection bias will be minimized by applying the same eligibility criteria on the control group as what was used for selecting the intervention group.

**9. Independent and dependent indicators**

The following outcome indicators will be used to quantify the effect of home vegetable gardens on households’ vegetable production and consumption:

1. Vegetable production expressed in kilograms per household member per year. Production data will be collected using a 12-month recall period divided into raining and dry seasons
2. Variety of vegetables grow over the past six months
3. The number of times vegetables are harvested in each season and the average amount harvested each time
4. The dietary intake of vegetables over a week
5. Quantity of vegetables consumed, expressed in grams per capita per day, will be calculated using a 24-hour recall method.

**10. Training**

A two-day intensive training session will be organized which will be divided into two parts: classroom teaching and hands-on practice in a demonstration garden. The content of the training will focus on container garden establishment, the importance of nutrients and their effect on health; the food value of commonly grown fruits and vegetables; simple food processing and preservation techniques to preserve the nutritional content of vegetables during cooking; preparation of nutritious and safe meals.

**11. Data analysis plan**

Difference-in-difference analysis will be used to measure impact. It compares the average change in outcome indicators over time for the intervention and control group.

The following model will be estimated using Ordinary Least Squares:

https://www.tandfonline.com/na101/home/literatum/publisher/tandf/journals/content/rjde20/2016/rjde20.v008.i04/19439342.2016.1231704/20161027/images/rjde_a_1231704_m0001.gif

where treatment is a dummy variable separating the intervention group from the control group and period is a dummy variable separating the baseline data from the follow-up data. The parameter δ quantified the impact of the intervention, which is the average treatment effect.

The pre-and post-project food consumption frequencies, dietary diversity, food consumption score and nutrient adequacy will be compared.

**GH2211-19: Evaluate the threshing efficiency of different maize shellers with regards to grain quality characteristics as influenced by different varieties and harvest timing**

**Lead: SARI: Dr Issah Sugri**

**1. Overall Objective:** Postharvest technologies and practices to provide options for the food, and feed sectors are tested and disseminated to farmers, through researchers, extension staff, and development partners.

**2. Specific objectives:**

1. Introduce, evaluate, adapt and disseminate improved postharvest technologies and practices to end-users.
2. Evaluate the threshing efficiency of different maize shellers with regards to grain quality characteristics as influenced by varieties, harvest timing and grain moisture.
3. To demonstrate and train beneficiary farmers on the operation and economic benefits of mechanized shelling.

**3. Research Question:**

1. A significant proportion of farmers time and energy can be saved by enhanced access to threshing machines
2. Efficient threshing operations can reduce postharvest losses of both small and medium holder farmers

**4. 1 Activity 1: Effect of variety, harvest interval and grain moisture on maize threshing efficiency**

Three maize varieties (Obantampa, Abontem and Omankwa) will be planted and harvested at maturity intervals of 1, 2, 3 and 4 weeks starting from harvest maturity. Threshing will be done using three options (Control/manual, Diesel-powered medium sheller and commercial power transmitted sheller). Simple harvest indices which farmers can follow without complex equipment will be used. The harvest indices scale 1: Cob is dry but most of the leaves above cob are green; 2: Cob is dry, but 3-4 leaves above cob are green; 3: Cob is dry, but last 1-2 leaves are green; 4: Cob is dry, and the entire plant is dried

**4.2 Activity 2: Activity 2: Threshing efficiency and performance characteristics of different maize shellers.**

Threshing efficiency (de-husking, shelling and cleaning) will be assessed through three types of threshing operation (manual, Diesel-powered medium shellers and commercial power transmitted shellers). Moisture characteristics associated with these periods will be characterized and modelled for decision making. Another study will involve a survey of common shelling machines utilized by farmers in 4 districts of Upper East Region. An interview guide will be developed to generate information on production operations, factors influencing farmers the use of shelling machines and associated challenges. Data to be collected include:

* Machine productivity
* % Cracked grain
* % Grain breakage
* % Whole Grain
* % Grain cleanliness
* % Threshing efficiency
* % Grain moisture

**4.2.1 Determination of threshing efficiency**

**4.1.1 Machine productivity**

Threshing machine productivity depends on the type of machine as well as the size and moisture content of the grain and threshing efficiency. It can be calculated from the equation:

Where q is machine production (), W is output mass (g) and T is time (min).

**4.1.2 Power Requirement**

This is the power consumed by a machine to perform a specific threshing operation. This can be expressed as:

P .v. I. cos

**4.1.3 Cracked grain**

Kernel crack is one most important factor contributing to maize breakage during threshing. It can be calculated from the ratio of cracked grain to total grain shelled:

Where, is the proportion of cracked grain (%); is the mass of cracked grain (g); is the total mass of the sample (g).

**4.1.4 Grain breakage**

The percentage of damaged and broken grain during the threshing process can be expressed as the ratio of cracked to total mass shelled:

Where is the percentage of breakage (%); is the mass of breakage grain (g), and is the mass of maize sample used (g).

**4.1.5 Whole grain**

Percentage of whole-grain represents the amount of undamaged grain during the threshing process:

Where, is the percentage of whole grain (%); is the mass of whole grain (g), and is mass of maize sample used (g).

**4.1.6 Grain cleanliness**

After threshing process, a randomized grain sample of 1kg is taken to calculate the percentage of clean grain, which is expressed as:

Where, is the percentage of grain cleanliness (%); is mass of sample (g), and s mass of impurities (g).

**4.1.7 Threshing efficiency**

Overall threshing efficiency is determined by using equation:

Where, is the threshing efficiency (%); is the initial mass to be threshed (g) and is the mass of the sample (g).

**5. Activity 3: Community Level Postharvest Demonstrations and Trainings**

Four participatory demonstration and training sessions will be conducted for 300 farmers (~50 to 75 participants per community) in 4 AR communities (Bonia, Gia, Nyangua, Sambligo). Training sessions will consist of 2-hours of technical information, and 2-hours of hands-on operation of the machines. Training messages will be focused on: benefits of using grain shellers, identifying appropriate harvest indices, determination of grain moisture, shelling performance of machine, grain cleaning, grain protection options and best grain storage practices.

**Datasheet 1: analysis of maize threshing practices, option and efficiency**

**Field Checklist**

GPS --------------------------------------

Community -----------------------------

Gender ----------------------------------

Age --------------------------------------

Education -------------------------------

Size of farm ----------------------------

Date of planting ----------------------- (Early June, late June, 1st July, 2nd week, 3rd week)

Date of harvesting --------------------(Early Oct, late Oct, 1st Nov, 2nd Nov., 3rd Nov. 4th Nov.)

Variety ---------------------------------

Maturity type: Extra early -------------- Early -------------- Medium --------- Late -----------

Average Yield -------------------------

2. Estimate the number of people who can do these activities for 1 hectare of maize

|  |  |  |
| --- | --- | --- |
| Operation | Number of people required | Cost of labour |
| Harvesting |  |  |
| Conveying to threshing field |  |  |
| Manual Threshing |  |  |
| Manual Shelling |  |  |
| Cleaning (winnowing) |  |  |
| Storage |  |  |
|  |  |  |

Identify, which of these operations is most difficult ----------------------------

Identify, which of these operations do you require mechanical threshers --------------

Have you ever employed the services of a threshing machine? Yes ---------- no ------------

Give a reason ………………….

What is the cost of threshing service --------------

Identify, which are the 2 most important challenges in the postharvest of maize

Access to labor ----------------- Cost of labor ---------------- Access to shelling machine -------- Intermittent rainfall ----------- No drying platform ------------ Cost of storage facilities ------ Insect pest damage ---------------- others -----

Identify, where will you store the maize grain.

Household store Mud silo -------- jute bags ----- Fertilizer bags ------PICS bags ------ others ---

Identify, how long will you often store the grain

1-4 months ------------------ 5-8 months --------------- 9-12 months -----------------

**Data Sheet 2: Analysis of maize threshing options and efficiency**

**Power Transmitted Shellers and Sheller Types**

**Checklist (Data)**

Community ----------------------------------------------------

GPS -------------------------------------------------------------

Type of sheller used ------------------------------------------

Cost of shelling/ commission ----------------------

Variety ----------------------------------------------------------

Date Harvested -------------------------------------------------

Size of farm (ha) -----------------------------------------------

Threshing rate kg/minute ------------- -------- or minutes/bags --------------------

Grain moisture ---------------------------------------------------------------------------

Weight of shelled cobs -----------------------------------------------------------------

Weight of husk -------------------------------------------------------------------------

Weight of gleaned grain from chaff --------------------------------------------------

Weight of scattered grain/ spillage ---------------------------------------------------

Weight of grain sample ----------------------------------------------------------------

* Weight of whole grain ----------------------------------------------------------
* Weight of broken grain --------------------------------------------------------
* Weight of chaff (inert materials) ---------------------------------------------

**Data Sheet 3: Analysis of maize threshing options and efficiency**

**Manual shelling practices**

**Checklist**

Gender ----------------------------------------------

Age --------------------------------------------------

Threshing (De-husking) time (Weight per hour) --------------

Shelling time (Weight per hour) ----------------

Winnowing time (Weight per hour) ------------

Cost of labor/day ---------------------------------

**Equipment List:** Record sheets, weighing scale, sampling bags, paper envelops, moisture meter, GPS,

shelling machine

**GH2212-19: Monitoring group dynamics among users of small-scale maize shelling machines in Northern Ghana**

**Lead: IITA: Dr Bekele Kotu**

**1. Objectives:**

* To assess and describe the dynamics and the rules of engagement among group members, non-group members, and other stakeholders with whom they are interacting to make use of the maize sheller
* To compare and contrast different user groups (with their particular composition of farm and farmer types) to determine which groups have been most successful in mechanization and why
* To reveal factors that hindered a successful implementation so that future user agreements may be shaped to avoid these hampering factors
* To examine how factors such as grain moisture content and machine use efficiency affect the quality of maize grains shelled
* To investigate the extent to which mechanization is promoted and implemented in agricultural development ordinances and policies in Ghana at various levels ranging from the community level, district level and national level

**2. Study locations**

The study will be conducted in 18 communities in three regions of Northern Ghana as listed below

|  |  |  |
| --- | --- | --- |
| Northern Region | Upper West Region | Upper East Region |
| Duko | Zanko | Nyangua |
| Tibali | Guo | Gia |
| Tingoli | Passe | Tekuru |
| Cheyohi #2 | Nyagli | Samboligu |
| Kprim | Goriyiri |  |
| Gbanjong | Goli |  |
|  | Papu |  |
|  | Gyilli |  |

**3. Method of data collection**

Data will be collected through periodic qualitative and quantitative interviews with group members, non-group members, artisans and other stakeholders using the following approaches:

* Individual interviews with group members: A semi-structured questionnaire will be prepared to guide the interviews and trained enumerators will be used to implement the interviews. Data will be collected on demography and resource endowments of farmers, maize production, the quantity of maize shelled using the machines and other methods, knowledge on the details of group constitutions, problems
* Interviews with group leaders: separate interviews will be conducted with groups leaders to collect data on group income, access of group members, and plans.
* In-depth interviews: in-depth interviews will be conducted with selected farmers. The farmers will be selected such that the three typologies of farmers (i.e. high resource endowed, medium resource endowed, and low resource endowed households as identified in Michalscheck (2019).
* Interviews with artisans and other stakeholders: this will be to examine the relationship between the maize sheller groups and other stakeholders who are expected to benefit from the relationship.
* Document review: Selected policy documents on agricultural development, annual development plans and reviews will be reviewed, and relevant stakeholders in the formulation and implementation of policies interviewed.
* Laboratory test: we collect samples randomly and test the moisture content and measure broken grains

**4. Analyses to be conducted**

* We compare groups in terms of quantitative economic benefits (such as net income at group level, net savings and investments at group level) in relation to the services stated in group constitutions. Using the individual-based data, we analyze levels of machine usage as measured by the quantity of maize shelled and the distribution of the quantities among users.
* We conduct a systematic comparison of written constitutions, followed by a collection of narratives on (1) the actual implementation of the constitution as well as (2) ongoing group dynamics. Group dynamics will further be explored by determining individual / sub-group-interests as well as their power shares (quantified) using the stick-score method described in Michalscheck *et al*. 2018[[62]](#footnote-63).
* The success or failure of a group will be measured by collecting narratives that allow a comparison between ‘group objectives’ as defined in the constitution and actual ‘group-level outcomes’. We also compare the group’s objectives and outcomes with the ‘expectations’ (increase in mechanization --> productivity/less labor) by Africa RISING.
* We explore factors that lead to the success or the failure of the communal maize sheller use. We then compare these factors among the intervention sites to determine common patterns and ‘the main lessons learnt’ to provide clear advice for the institutional set-up of the communal ownership of agricultural machinery, using the example of the maize sheller. We will furthermore engage with partners and other research for development project to share the lessons learnt and eventually to add their experience to our assessment, too.
* We analyze the effect of grain moisture content on grain quality when using the shelling machines.

**Subactivity GH3111-19: Strengthen the technical, managerial and organizational capacities of the major actors in small ruminants value chain through existent institutional structures such as Farmer-Based Organizations (FBO), District Assemblies (DA), Community Based Organizations (CBO), traders Associations, Transports and input Dealers Association**

**Lead: ILRI/ ARI: Dr Augustine Ayantunde**

**1. Introduction:**

Ghana is a meat-deficit country and a net importer of livestock products. Increased growth in the value chain of the small ruminant subsector would reduce the deficit and provide several jobs along the chain for youth and women who have been the most vulnerable in society. There are many important issues along the value chain that are not dealt with by the existing institutional structures, nonetheless, together constitute a major lapse in the livestock development effort. These include inadequate linkages with relevant agencies and bodies such as Ministries of Agriculture, Water Resources Commissions, as well as Ministry of Trade that would help to enhance livestock development. There is little awareness of livestock stakeholders on many issues and opportunities geared towards livestock development, low advocacy for livestock development and low involvement of stakeholders in program implementation and monitoring for effectiveness. Efforts should be directed at the functional organization of smallholder small ruminant farmers into more commercially-minded groups with the ability for bulk production to supply major markets in the country with small ruminants, particularly at festive occasions. Therefore, this sub-activity is proposing that if we can strengthen the technical, managerial and organizational capacities of the major actors in the small ruminant value chain, it will go a long way towards addressing some of the aforementioned challenges. The major actors in the small ruminant value chain include MoFA, small ruminant producers, traders and processors as well as the service providers.

**2. Objectives**

The objectives of this project are to:

* improve the technical, organizational and managerial capacities of small ruminant value chain actors in northern Ghana
* increase small ruminant value chain input and output services
* strengthen linkages among small ruminant actors and
* increase women and youth participation in small ruminant value chain activities

**2.1 Hypothesis**

The following null hypotheses will be proposed:

* Establishment of an innovation platform will not improve small ruminant value chain input and output services
* Interventions will not lead to an improvement of the technical, organizational and managerial capacities of small ruminant value chain actors in northern Ghana
* Interventions will not lead to the strengthening of linkages among small ruminant actors
* Women and youth participation in small ruminant value chain activities will not be increased by interventions

**3. Methodology**

**3.1 Baseline information gathering**

A baseline survey will be conducted in two intervention districts. The baseline information will focus on the quality of animals traded, the level of organization of existing small ruminant value chains, sales, level of adoption of proven technologies by actors and linkages to other actors and markets. The research team will visit Kassena-Nankana Municipal to inform small ruminant value chain actors about the objective of the project and proceed with baseline information gathering. Later, the team will visit Wa Municipal and Wa West District of the Upper West Region also to inform these district authorities about the project and collect baseline data.

**3.1.2 Preliminary Meetings with Small Ruminant Value Chain Actors**

*Meeting with Staff of the Municipal Agriculture Office*

In each project location, the team will first visit the Municipal Director of Agriculture.

*Meeting with Executives of the Livestock Traders Association*

Next, the team will meet with the executives of the Small Ruminant Traders’ Association in each project location. The team will seek permission from the executives of the Associations to witness the small ruminant market on a market day to understand what goes on around the market linkages between the producers and buyers.

*Meeting with Actors at Village/Community Level*

During the visit to project locations to gather baseline information, the team will meet with a cross-section of the farmers at Siriyilli, Passe, Zanko and Guo communities in Wa West District, and Gia, Bonia, Tekuru and Nyangua in Kassena-Nankana Municipality. From these communities, the team will request for two outstanding small ruminant producers to be selected for further screening for participation in the innovation platform for each of the two project enclaves. Producers with some level of education as well as those who have ever won an award will be considered good candidates for the innovation platform.

**3.2. Visit Ouagadougou to learn about the functioning of the small ruminant value chain in Burkina Faso**

The team will visit Ouagadougou, Burkina Faso to interact with stakeholders who worked on small ruminant value chains. The stakeholders will include the Director-General of Animal Production Directorate, Resilience and Economic Growth in the Sahel **(**Regis-AG), Environmental Institute for Agricultural Research (Institut de l'Environnement et Recherches Agricoles) (INERA), Innovation Platform for Small Ruminants Value Chains (IP filiere petits ruminants) and Tanghin small ruminant market.

**3.3 Innovation Platform Workshop**

Actors of the small ruminant value chains in intervention districts will then be brought together in an Innovation Platform. The main platform members will include MoFA, small ruminant producers, traders and processors as well as the service providers. The platform members will be briefed on the findings of the small ruminant value chain in Ghana and how it is organized in Burkina Faso. Enriched with information, the innovation platform members will prioritize recommendations that would improve the small ruminant value chain sustainably. A workshop will be organized for them to prioritize constraints. The platforms will organize regular meetings. Both biophysical and institutional constraints will be addressed to make it profitable to adopt proven technologies and improved practices. Individuals and teams will be tasked to address prioritized constraints. Processes and results will be documented systematically.

The platforms will be responsible for identifying platform members for the execution of specific tasks such as planned regular meeting and ensuring that any pressing or urgent issues that affect the small ruminant value chain are brought to the table. Each Platform will have its executive made up of a Chairperson, a Vice, Secretary and Treasurer. The role of ARI will be facilitative and will also be with technical backstopping and providing linkages to key service providers when a need arises. The platforms will be self-sustaining by conducting stakeholder mapping and analysis around different actors in the small ruminant value chain. Their capacities will be built-in governance mechanisms and record-keeping among others. Frequency of platform meetings will be determined by its members and based on the number of tasks to be accomplished within a specified time. It may, therefore, be quarterly.

**3.4 Implementation of prioritized interventions**

Women and youth participation at both household and supra-household levels will be increased by inviting more women to benefit from project activities. An evaluation survey will then be conducted to measure changes in the organization, technology adoption and linkages in the small ruminant value chains. The entire process will be summarized in a handbook that will serve as a guide for developing small ruminant value chains. This handbook on how to develop small ruminant value chain will contribute to the finalization of the Africa RISING West Africa handbook.

**3.5 Highlight SI indicators and their defining metrics**

The SI indicators will include small ruminant productivity, quality of farmers’ soils for crop cultivation, income from their small ruminants, labor requirements, building the capacity of women in record keeping and trading for profit, youth and the vulnerable, engaging in collective action, contributing to improved nutrition and ability of farmers to try new things. The project will do a preliminary selection of farmers and other actors to represent the various interest groups in the innovation platform. A final selection will be done just before the day of the innovation platform meeting. Small ruminant productivity and soil quality will then be determined for farmers on the final list of selected farmers. Incomes they make and their labor input into small ruminant activities will also be determined. Concerning gender issues, women and youth will be part of the innovation platform and decision making. Information and contracts will be shared. Farmers will be introduced to new ways of doing things.

**3.6 Partnership/linkages with other projects**

The project will link up with various regional and municipal/district departments of agriculture responsible for the zones in which the projects are located. The project will also link up with Centre for Indigenous Knowledge and Organizational Development **(**CIKOD), Ghana Developing Communities Association (GDCA) and the Directorate of Animal Production in Burkina Faso because they are all involved in livestock value chain development.

**3.7 Data collection**

The team will employ an unstructured interview method to intercept value chain actors in both Navrongo and Wa small ruminant markets. The unstructured method will be a random selection of members. The team would not pre-determine the number of actors. This method will make conversation during one-on-one interaction with actors very open and will allow actors to express themselves freely. Brainstorming sessions will play a key role in decision-making within the Innovation platforms. Monitoring and evaluation will be carried out.

**3.8 Data analysis**

Causal and Effect diagrams and matrix ranking will be used to analyze data. Descriptive statistics will also be used to summarize data that would be presented as tables and graphs.

SPSS will be used to analyze the effect of interventions and mean separation would be done for detection of significant differences at 5% level of significance.

**GH3211-19: Evaluate risk and vulnerability as well as resilience within maize-cowpea living mulch systems in relation to smallholder farmers’ livelihoods**

**Lead: KNUST: Dr Wilson Agyei Agyare**

Throughout the resilience assessment process, the project assessment team will respond to ***Five Guiding Resilience Questions*** by applying resilience thinking to the maize-cowpea living mulch system in relation to well-being outcomes (Mercy Corps[[63]](#footnote-64))

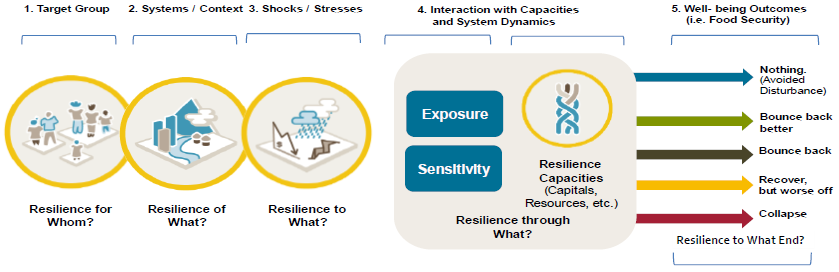
**1.** **Resilience *for Whom?*** The smallholder farmers and their attributes that include the location (rural), demographic factors (sex, age, ethnicity) and livelihood (agriculture, markets, labor dynamics).

**2.** **Resilience *of What?*** The enabling environment, including formal and informal institutions at the community level, social, ecological and economic factors that impact smallholder farmer’s ability to anticipate, absorb and adapt to risks and reduce vulnerabilities.

**3. Resilience *to What?*** The complex and compounding shocks and stresses that impact smallholder capacities to achieve development outcomes.

**4. Resilience *through What?*** The absorptive, adaptive and transformative capacities that strengthen the ability of smallholder farmers to mitigate risk and reduce vulnerability e.g. Africa RISING technologies such as improved seed varieties and good agronomic practices.

**5. Resilience *to What End?*** The primary wellbeing or development outcomes for which we want to build resilience mainly looking at the 3 principal goals of AR: improved livelihoods, increased food security and an enhanced natural resource base.



**6. Conceptual framework** for understanding resilience, in particular, social, political, economic, and ecological context based on the five resilience questions[[64]](#footnote-65).

Risk, vulnerability, resilience, and livelihood have been conceptualized and framed using a framework adapted from the Mercy Corps. They are related as depicted by the framework. They will be evaluated through the KASA framework (KASA: Knowledge, Attitude, Skills and Aspirations) as well as the SIAF framework using a set of collectively co-identified indicators with the smallholder farmers.

To develop effective, measurable resilience-building strategies, we will consider the complex interactions that exist between risks, people and the socio-ecological systems in which they live. These interactions occur at various spatial and temporal scales and are inherently dynamic. Thus, when shocks hit a system, they do not occur in isolation; rather, they interact with multiple factors that can compound their impact and provoke downstream effects. Understanding social-ecological systems, for instance, requires understanding how people think, engage with one another and their environment, and react to and affect changes from the local level to the community, regional and national level. For this subactivity, we shall principally consider the local to community levels and will use biophysical and ecological modeling, focused group discussions and economic tools as well as the SIAF to allow for a systems approach to the desired analysis.

This sub-activity will follow USAID’s resilience guidance notes[[65]](#footnote-66) and will entail 4 steps:

* Step 1: Planning and design to determine the purpose (on how will this analysis be used, by whom), scope and scale of the assessment as well as the level of effort while taking stock of existing data, identifying knowledge gaps and creating a research plan to respond to key questions on resilience capacities and risks. This will be followed by
* Step 2: Data Collection which will entail qualitative and quantitative data from primary and/or secondary sources to fill knowledge gaps identified in Step 1.
* Step 3: Analysis. Combine and interpret data to answer key questions as determined in Step 1.
* Step 4: Strategic Planning. Translate findings into appropriate outputs, based on the purpose of the assessment. Possible outputs include resilience-building programmatic strategies. In order to measure absorptive, adaptive and transformative capacities of resilience at the household and community scales, we intend to link aspects of resilience to the SIAF at the aforementioned scales

**GH-4111-19: Conduct simulation and other socio-economic analyses of selected SIU technologies/ practices for different farmer contexts, to have a better understanding of the adoption potential of these proven technologies and opportunities for scaling up**

**Lead: STEPRI: Dr Abdulai Adams**

**1. Research Objectives**

1. To analyse the potential gains/losses at farm level per farm type, per capita incomes and poverty rates of farms that adopt SI technologies/practices (System 2-made of different scenarios) compared to those who remain with conventional practices (System 1) to inform policy decisions and private entrepreneurs which SI technologies to promote for greater impact.
2. To determine the potential adoption rates of the adapted technology among smallholder farmers
3. Determine the potential uptake of AR SI technologies without project intervention and assess the profile of likely implementers to influence policymakers at different hierarchies (community, district and national).

**2. Research Questions**

1. What are the potential gains in net per farm returns, per capita incomes and poverty rates of farms that adopt SI technologies/practices (System 2-made of different scenarios) compared to those who remain with conventional practices or “business as usual” (System 1)?
2. What are the potential losses in net per farm returns, per capita incomes and poverty rates for smallholder farms in Northern Ghana with and without adaptation?
3. What are the potential adoption rates of the adapted technology among smallholder farmers?
4. What is the potential for uptake of AR SI technologies - which types of farmers are likely to use them and with what expected outcomes?

**3. Types of Data and Source of Data**

Quantitative data will be collected for the study. The data include household size, number of farms, farm sizes, livestock flock sizes, quantities and prices on inputs such as seeds, labor, fertilizer and manure, outputs on crop yields, non-agricultural income, land use and net returns on crops and livestock. The data will be obtained from primary and secondary sources.

The primary source is farmers (household heads) in selected communities in the district who will be interviewed using a semi-structured questionnaire to be developed. The secondary source of data will be obtained from scientific validated Africa RISING sustainable intensification technologies (experimental, crop models and Representative Agricultural Pathway (RAPS) data).

**4. Sample Size, Sampling Technique and Data Collection Procedure**

A total sample size of three hundred (300) farmers will be taken from the three Northern regions (Upper West, Upper East, and Northern Regions) for the survey, 100 farmers from each region.

Stratified and systematic sampling techniques will be used. Stratified sampling will be used to divide the population of the communities into two subgroups. That is, Africa RISING communities and Non-Africa RISING communities.

Systematic sampling will be used to select every “Kth” household unit from a random starting point in each stratum. The household heads will be selected because they manage and coordinate the day-to-day activities of the household including farming.

**5. Conceptual and Theoretical Model**

1. The model will simulate the proportion of farms that would adopt the system and the proportion that does not adopt
2. Based on the adoption rate of the system 2, the TOA-MD model simulates selected economic, environmental and social impact indicators for adopters, non-adopters and the entire population

The TOA-MD model is a unique simulation tool for a multidimensional impact assessment that uses a statistical description of a heterogeneous farm population to simulate the adoption and impacts of the new technology or a change in environmental conditions, or in ecosystem services supply. We will focus only on the adoption and impacts of the new technologies disseminated.

The model is designed to simulate what would be observed if it were possible to conduct a controlled experiment in which a population of farms is offered the choice of continuing to use the current or “base” production system (System 1) or to adopt a new production system (System 2) under Sustainable Intensification (SI) practices. Using survey, experimental and crop models data in combination with SI scenarios, the TOA-MD model simulates and compares economic, social and environmental outcomes from the two systems (1 and 2) (Antle and Valdivia, 2010[[66]](#footnote-67)).

System profiles are summarised as follows:

Suppose that a farmer at a site (s) is using a production system (h) with inputs prices (p) earns returns/ha equivalent to . When the production system changes, because of a change in technology, expected returns at each site also change. The effect on a farm’s returns of changing from system *j* to system *k* is Thus, if is positive it represents the loss/ gain associated with switching from one system to another.

The proportion of farms using system 2, referred to as the adoption rate of system 2 is given by the cumulative distribution function , and the share of farms using system 1 is *r*(*p*, 1, *a*) ≡ 1 – *r*(*p*,2,*a*). In addition to economic outcomes, Antle *et a*l. (2014)[[67]](#footnote-68) considered other environmental or social outcomes *z* (a, h). In this case, the distribution for the sub-population using each system is the joint outcome distribution between and  truncated according to for system 1 and for system 2 (Antle *et al*., 2014[[68]](#footnote-69)):

…….(2)

Thus, the outcomes (economic and social/environmental) are indexed by k = v, z while systems are indexed by h = 1, 2.

Antle (2011[[69]](#footnote-70)) and Antle *et al.* (201451) note that indicates a distribution that is truncated from below by ***a*** for system 1, and truncated from above by ***a***for system 2, whereas shows a distribution defined over the entire population. The joint distribution of and  in a population using both systems is a mixture of the distributions defined in equation (a) with mixing proportions.

**6. The logical structure of the model**

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**Sub-activity:** **GH 4112- 19: Evaluate the impact of sustainable intensification practices on household welfare, poverty, perceived shock, the environment, and food and nutrition security in northern Ghana**

**Lead: IITA: Dr Shaibu Mellon Bedi**

**1. Locations**: Fifty communities in three northern regions of Ghana (20 in the Northern Region, 20 in the Upper West Region and 10 in the Upper East Region)

**2. Objectives:**

* To analyze the factors that influence farmers’ decision to adopt SI practices
* To examine the effects of adopting SI practices on 1) Crop yields; 2) Household welfare; 3) Return on investment; 4) The environment; 5) Food and nutrition security; 6) Poverty rates and 7) Perceived shocks
* To estimate the effectiveness of using nudges (e.g., free inputs and training) to induce adoption of SI practices.

**3. Data and sampling procedure**

Data for this study will be collected following the GARBES sampling framework (see Tinonin *et al*., 2016[[70]](#footnote-71)). Given the limited funds available, we will resample farmers from the list of farmers used in the GARBES. A multistage sampling technique (i.e. cluster random samplings) used during the baseline survey will also be employed. Power analysis will be conducted to estimate the total sample size required to detect changes in outcomes (e.g. yield, income, etc.) associated with the interventions. On the whole, 700 farm households will be sampled across all 50 communities in the three regions. Demographics, socio-economics, agricultural production, marketing, and food and nutrition security data will be collected.

**4. Data analysis**

A variety of quantile regression methods (e.g. changes-in-changes, difference-in-difference, etc.) will be used to address the objectives.

**Sub-activity: GH 4113-19: Farmers’ preferences for technology attributes and their associated benefits in cereal-legume systems of northern Ghana**

**Lead: IITA: Dr Bekele Kotu**

**1. Objectives**

* Identifying important attributes associated with maize production technologies including improved varieties and agronomic practices) as perceived by farmers
* Assessing the differences in the technology preferences among farmers with respect to gender and farmer typologies
* Refining technology targeting relevant to farmers’ preferences and providing feedback to researchers, extension agents and development practitioners the key findings of the study

**2. Sampling and data collection**

We will work with farmers who participated during the Ghana Africa RISING Baseline Survey (GARBES) (see Tinonin *et al*., 2016[[71]](#footnote-72)). We will consider all GARBES farmers in 25 randomly selected sub-sample communities. The target sample size will be about 650 farmers. Before the household survey, we will conduct focus group discussions to collect qualitative data on farmers’ preferences and related issues. Discussions with researchers and other key informants will be made. The data from the focus group discussions and the key informant interviews will be used to design the household survey and prepare the questionnaire. The survey will be organized following a choice experiment design in which respondents are asked to choose from the list of different hypothetical technology profiles presented to them. The choice sets will be fixed based on the discussions we will have with the farmers, researchers, and other knowledgeable individuals or groups regarding the farming systems in northern Ghana and the performances of different agricultural technologies.

**3. Analysis**

The analysis will follow advanced econometric models suitable for discrete choice experiments. These include Multinomial Logit model (MNL), Mixed Logit (MXL), Generalized Logit (GMNL), and Latent Class Model (LCM). All, except the MNL, assume heterogeneities in individual preferences.

**Sub-activity GH4121-19: Utilize ICT and GIS tools as a means to share information (agronomic, climatic and market services) and scale-out Africa RISING technologies in collaboration with strategic partnerships in the Region**

**Lead: KNUST: Dr Wilson Agyei Agyare**

**1. Introduction**

*Preview of the uploaded content on web and android*

This sub-activity uses an E-extension initiative conducted through a platform that currently hosts 350 farmers in Northern Ghana. The initiative will be a collaboration between IITA and ESOKO. The registered beneficiaries have phones ranging from the simple keypad type to the smartphone- and they receive the updated and certified Agri-tips via SMS throughout the production season using the results from the cropping calendar and post-production period thus providing reliable, relevant and timely information on postharvest interventions and market linkages.

Farmers will be reached using SMS information services and the information will go beyond the target farmers to other farmers with WorldCover to enhance further scaling. Dissemination of SMS messages on agronomy will be accompanied by Agri-tips on pre-harvest, harvest, post-harvest technologies, storage and marketing. The Platform will also host educative videos and will link up agricultural extension agents with updated information for further sharing with farmers.

The current platform offers automatic and personalized SMS alerts and can have options for bulk SMS, SMS polling, surveys, and interactive video training modules. The bulk SMS option means that AR in partnership with ESOKO acts as an SMS aggregator, delivering SMS messages to subscribers’ handsets through the mobile network operator’s (MNO) short message service center (SMSC). The information is delivered to all registered subscribers independent on which MNO they have affiliated to.

**2. Goals**

This sub-activity intends to:

1. Target special content for youths and women:
   * Use of smartphones is a plus for youths since they easily identify with it and they are attracted by the usage of videos and returns in investment models for the different crops. If resources permit, this will be enhanced by providing information on crops such as maize and vegetables that have medium to short maturity cycles and high returns which are more attractive to youth.
   * Special content on nutrition, family health care, reproductive health, insurance will be shared by targeting women in combination with the power of local radio programs through subactivity led by UDS on the use of the power of radio to empower nutrition.
   * Bring on board Agribusinesses (for sustainability): Agribusinesses have an opportunity to include their products and catalogues which creates sustainability of the Platform.

**Tabular summary: Engage ICT and GIS tools as a means to share information and scale-out Africa RISING technologies in collaboration with strategic partnerships in the Region**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **ACTIVITY** | **PROTOCOL** | **Period** | **INDICATORS** | **MEANS OF VERIFICATION** | **RESPONSIBLE STAFF** |
| 1 | ICT and GIS tools are being used to share information to scale-out Africa RISING technologies | 1. Continue to log on farmers to ICT 2. Share information ICT 3. Monitor ICT/GIS tool for info sharing | Aug-Dec | (a) No. farmers added to list  (b) No. of farmers accessing ICT facility | 1. Kobo Tool Box developed 2. ESOKO engaged 3. Farmer companion guide & brochure 4. Guidance for AEAs | Wilson Agyei-Agyare, B.O. Antwi, Fred Kizito, |
| 2 | Compile and publish the seasonal calendar for use by farmers and development partners | a. Review seasonal calendar  b. Carry out training for efficient use of the seasonal calendar | 08-2019 –02- 2020  Apr–May 2020 | a. Draft manuscript being prepared  b. No. of training sessions carried out | a. Published seasonal calendar  b. Report on training sessions | Wilson Agyei-Agyare, B.O. Antwi, Fred Kizito, |

**Sub-activity GH4311-19: Matching agricultural technologies to farmers and their context**

**Lead: WUR: Dr Jeroen Groot**

**1. Introduction**

Increasingly, mobile phones and other ICT services are used to provide information and advice to farmers to facilitate learning, but support to targeting and scaling of agricultural technologies through ICT tools is scarce. ICT-based targeting and scaling approaches should not be considered a silver bullet, although they can increase the reach and reduce the costs of technology dissemination compared to traditional village extension services.

Sophisticated models of technology integration in farming activities exist, but they are often very data-intensive and do not extend beyond the farm level. Muthoni *et al*. (2017)[[72]](#footnote-73) utilized spatially gridded biophysical and socio-economic layers to generate what they called “sustainable recommendation domains” (SRDs) that could be targeted for scaling specific technologies. The effectiveness of the suitability assessment can be further refined as long as the features of individual farms are considered and directly related to technology characteristics during the targeting phase. Innovations in coupling knowledge among site characteristics, household features and technology attributes with the SRDs is needed to guide spatial targeting of suitable technologies.

The FarmMATCH approach explicitly tries to fill this knowledge gap, facilitating the matching between agricultural technologies to farms and their context. It contains 1) a learning and matching algorithm that identifies the most suitable and promising technologies for different farm types, and 2) a data mining and signaling algorithm that identifies hotspots of suitability of technologies and potential adopters. The matching algorithm combines contextual, farm and technology characteristics to create a ranking of the suitability and adoption probability of available innovations.

**2. Objectives**

* Test and improve the ‘matching’ algorithm on a large dataset
* Determine the ease of scarce data collection at farms
* Obtain feedback from farmers on the technology priority lists
* Develop a mechanism for feeding collected data to the database and improve algorithm learning
* Develop the ‘signaling’ algorithm

**3. Data collection**

GIS and GARBES databases for intervention areas in Northern Ghana will be used to select 1 km2 grid cells with surveyed households. A minimal set of supplementary data on farm and household features and on-farm technologies and practices may be collected. ARBES data will be incorporated into a MySQL relational database for easy querying.

We select 15-30 grid cells of 1 km2 from the three Northern regions of Ghana (NR, UER, UWR), so 5-10 cells per region. These cells differ in biophysical conditions (soil, rainfall, etc.) and socio-economic circumstances (e.g. distance to market). Moreover, within these cells we have at least 10 households sampled within the GARBES database collected by IFPRI; if this is not the case then additional data collection is required. In total ca. 300 farms will be included. There should also be diversity among the sampled households in the grid cell. For each household, we analyze in particular the main, easy to collect farm and household features (size, objectives, livestock, crop number, % off-farm income, etc.) and relate these to the farm practices and project-proposed technologies and techniques. The matching algorithm combines the GIS-derived data on biophysical conditions and socio-economic context circumstances with the farm features, to estimate the probability of use of the various technologies and techniques. The data set will be divided between a training set (n=200-240) and a testing set (n=60-100).

**Research Protocols Mali 2019-2020**

**Sub-activity MA1111-19: Evaluating the effect of different fertility sources on the productivity of sorghum varieties across different rainfall gradients in the Sudanian zone of Mali**

**Lead: ICRISAT: Dr Zemadim Birhanu**

**1. Objectives:**

1. To better understand the physiological functioning and yield potential of sorghum varieties under different fertilizer management (livestock manure and inorganic fertilizer) across different rainfall gradients and soil characterizations.
2. Evaluates the productivity of sorghum using the validated crop simulation models (APSIM and DSSAT) under current and future climate conditions based on observations and Global Climate Models (GCMs) outputs
3. Determine the marginal cost-benefit responses of different fertilizer sources based on current farming practices.

**2. Design**

Split-Plot Design (See figure below)

Replications: 4

Main Plot = Fertilizer

The treatments include nine (9) different fertility sources [synthetic fertilizer, cow manure, poultry manure and the combination of cow manure] and a control.

Plant population will be 44,440 hills/ha (0.75m between rows and 0.3m between hills) and thinned to 2 plants/hill two weeks after planting. Insecticide EMACOT 019 EC will be used according to local recommendations (60 ml mixed with 6 liters of water for one hectare, applied three times during the growing season) against stem borer infestation.

The fertility treatments will be as follows:

* DAP (41:46:00) @ the rate of 230kg/ha
* DAP micro-dose (3g/hill)
* Cow manure (100g/hill)
* Cow manure (50g/hill) + poultry manure (50g/hill)
* DAP (3g/hill) + Cow manure (100g/hill)
* Poultry manure (50g/hill)
* Poultry manure (100g/hill)
* Poultry manure (150g/hill)
* Poultry manure (100g/hill) + DAP micro-dose (3g)
* Control

Note: Fertilizer application to be done at sowing

Sub Plot = Variety

Three (3) varieties of sorghum: Soumba, CSM335 and Fadda.

**3. Economic data to be collected**

1. Cost of seed
2. Cost of fertilizer
3. Cost of cow manure
4. Cost of poultry manure
5. Labor cost

**4. The field layout is as follows**

Each plot size is 5 rows, 5 m long

1. Plot size: 5 rows, 5m long
2. 2 m between replications
3. 1 row blank (0.75m) between sub-plots (3 plots)
4. Spacing – 30cm intra-row and 75cm inter-row spacing
5. Sowing will be done at a depth of 3-5cm deep
6. Thin the plants to 2 plants per hill after establishment, 2 WAS

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 430  REP IV | 429 | 428 |  | 427 | 426 | | 425 | |  | 424 | | 423 | | 422 | |  | 421 | | 420 | | 419 | | |  | 418 | | 417 | | 416 | |
|  | 1m |  |  |  |  |  | |  | | |  | |  |  |  | | |  | |  | |  |  | | |  | |  | |  |
| 401 | 402 | 403 |  | 404 | 405 | | 406 | |  | 407 | | 408 | | 409 | |  | 410 | | 411 | | 412 | | |  | 413 | | 414 | | 415 | |
|  |  |  |  |  |  | |  | |  |  | |  | |  | |  |  | |  | |  | | |  |  | |  | |  | |
| 330  REP III | 329 | 328 |  | 327 | 326 | | 325 | |  | 324 | | 323 | | 322 | |  | 321 | | 320 | | 319 | | |  | 318 | | 317 | | 316 | |
|  |  | 1m |  |  |  | |  | |  |  | |  | |  | |  |  | |  | |  | | |  |  | |  | |  | |
| 301 | 302 | 303 |  | 304 | 305 | | 306 | |  | 307 | | 308 | | 309 | |  | 310 | | 311 | | 312 | | |  | 313 | | 314 | | 315  50 m | |
|  |  |  |  |  |  | |  | |  |  | |  | |  | |  |  | |  | |  | | |  |  | |  | |  | |
| 230  REP II | 229 | 228 |  | 227 | 226 | | 225 | |  | 224 | | 223 | | 222 | |  | 221 | | 220 | | 219 | | |  | 218 | | 217 | | 216 | |
| 1 |  |  |  |  |  | |  | |  |  | |  | |  | |  |  | |  | |  | | |  |  | |  | |  | |
| 201 | 202 | 203 |  | 204 | 205 | | 206 | |  | 207 | | 208 | | 209 | |  | 210 | | 211 | | 212 | | |  | 213 | | 214 | | 215 | |
|  | 2 m |  |  |  |  | |  | |  |  | |  | |  | |  |  | |  | |  | | |  |  | |  | |  | |
| 130  REP I | 129 | 128 |  | 127 | 126 | | 125 | |  | 124 | | 123 | | 122 | |  | 121 | | 120 | | 119 | | |  | 118 | | 117 | | 116 | |
|  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 101  5 m | 102 | 103 |  | 104 | 105 | | 106 | |  | 107 | | 108 | | 109 | |  | 110 | | 111 | | 112 | | |  | 113 | | 114 | | 115 | |

**FIELD LAYOUT DESIGN FOR SORGHUM FERTILITY STRATEGY**

70.5

5 rows

**5. Measurements**

Soil samples will be taken in each location before planting at the following depth (0-20, 20-40, 40-60, 60-80cm).

**6. Data will be collected as described in Fig 2 below**

6.1 Non- Destructive measurements (NDM) include:

1. The number of leaves per plants - Number of leaves per plant from emergence to flag leaf @ 15 days interval will be recorded from 4 tagged plants in each plot.
2. Number of tillers- number of tillers will be recorded at 15 days interval from the 4 tagged plants till physiological maturity.
3. Days to 50% flag leaf-Number of days from sowing to the appearance of 50% flag leaves will be recorded appropriately
4. Number of days to 50% flowering: The number of days from sowing to when 50% of the plants in each plot had flowered will be recorded.
5. The number of days to maturity: The number of days from sowing to when the plants reach physiological maturity will be taken and recorded.
6. Chlorophyll content (SPAD): Chlorophyll content will be recorded using SPAD-502 chlorophyll meter (Konica-Minolta); a hand-held, self-calibrating, convenient, and non-destructive lightweight device used to calculate the amount of chlorophyll present in plant leaves. The record will be taken at 3, 6, 9, 12 and 15 WAS (depends on the variety)
7. Leaf Area Index (LAI) and photosynthetically active radiation (PAR): This will be recorded as the spectral range of solar light from 400-700nm that is used by plants in photosynthesis as the rate of photosynthesis directly relates to the penetration of light through the canopy. The PAR will be measured using PAR sensor (Accupar, LP-80). LAI and PAR at 3, 6, 9, 12 and 15 WAS depend on the genotypes
8. Plant height: It will be measured using long meter ruler at 3, 6, 9, 12 and 15 WAS (depends on the variety)

6.2 Destructive measurements (DM) – will be taken from 30 DAS, 50 DAS, 70 DAS, 90 DAS and harvest. A pre-identified 4 plants (equivalent of 1m2) will be cut down in row 2 and 5, thereafter take the fresh weight and dry weight accordingly.

6.3 At harvest- the parameters include;

* Number of hills per plot at harvest area
* Number of stands per plot at harvest area
* Panicle number per plot
* Panicle weight per plot
* Grain weight per panicle (g)
* Grain weight per plot (g) (to be converted to yield in kg per hectare)
* Stover yield per plot(kg) (to be converted to yield in kg per hectare)



**Fig. 2:**









**Sub-activity MA1112-19: Understanding soil fertility management in cereal cropping systems in southern Mali**

**Lead: ICRISAT: Dr Zemadim Birhanu**

**1. Objectives**

**1.1 Objective 1: Assessing nutrient flows and nutrient balance under different soil fertility conditions**

**1.1.1 Method**

The activity is a continuation of the 2018 experiment.

**1.1.1.1 Farmer selection**

In 2018, farmers were selected in the three Africa RISING intervention villages (Zanzoni, Sirakélé, and N'golonianasso) in the district of Koutiala. In 2018 a total of 45 farmers were interviewed corresponding to 45 farms in the three villages. In each village 15 farmers were selected using the systematic random sampling method out of the total farmers present. Immediately after the engagement of each farmer, individual surveys were conducted in two stages—the farming inventory survey and the farming monitoring survey. The methodology is repeated in the year 2019.

**1.1.1.2 Farm inventory survey**

The inventory represents the first step in nutrient monitoring and consists of collecting baseline information on the demographic structure of the household representing the population and the number of men, women, and children per farm with their respective ages. For agricultural equipment, the type and number will be collected as well as the type and number of crops and animals. In the three villages, a total of 45 farmers will be interviewed during the rainy season 2019.

The approach was based on individual interviews with the head of the family who could be accompanied by the eldest son. Questions were structured in such a way to have precise information. For example, for the number of people in the family, the respondent could be asked to present his family notebook as a supporting document, especially for age determination.

**1.1.1.3 Farming monitoring survey**

The objective of the monitoring survey is to track the use of biomass and grain stocks, animals, and dynamics within the population. From January to February 2019, the first monitoring survey was conducted with the 45 farmers who had been surveyed for the inventory earlier in August 2018. A monitoring sheet was designed for collecting information on inputs such as organic matter (cattle, goat, and sheep manure, compost), mineral fertilizer (NPK), and urea. The number of equipment and animals was also monitored as well as biomass and grain across each farm. From June 2019 to January 2020 two series of surveys will be conducted with the same 45 farmers to capture the intra- and inter-farm dynamics.

**1.1.1.4 Method of analysis**

All variables (population, biomass, yield, etc.) will be quantified at different times of measurement as well as the yields of the main crops (maize, millet, sorghum and cotton) in the farm versus soil nutrient content. Variation of different indicators will be analyzed according to farm resource endowment status. Principal component analysis of the farm characteristics will be determined as well as the nutrient flow diagram regarding farm resource endowment.

**1.2 Objective 2: Developing strategies for composting and improving nutrient use efficiency for sustainable soil fertility management.**

**1.2.1 Method**

From January to April 2019, two types of heap compost were produced with cotton stem in the technology park as well as in the farmers’ fields. During the rainy season, field experimentation with the two compost treatments will be conducted at farmer’s fields as well as in the technology park. Each farmer will be experimenting with one of the two composting treatments. Dual-purpose sorghum variety (Soubatimi) will be used across all the experiment including in farmer’s field.

The treatments include the following:

* Zero (no application of compost and no mineral fertilizer)
* Control practice 1 (100kg/ha of DAP)
* Control practice 2 (40kg/ha of DAP by micro-dosing)
* Compost practice (farmers compost without cotton stem 5t/ha by spreading) and no fertilizer
* Compost practice (farmers compost without cotton stem 2.5 t/ha by micro-dosing) and no fertilizer
* Compost practice (farmers compost without cotton stem 5t/ha by spreading) + (100kg/ha of DAP)
* Compost practice (farmers compost without cotton stem 2.5 t/ha by micro-dosing) + (100kg/ha DAP)
* Compost 1 with cotton stem 2.5t/ha by micro-dosing + (100kg/ha of DAP)
* Compost 1 with cotton stem 5t/ha by spreading+ (100kg/ha of DAP)
* Compost 2 with cotton stem 5t/ha by spreading + (100kg/ha of DAP)
* Compost 2 with cotton stem 2.5t/ha by micro-dosing + (100kg/ha of DAP)

Experimental plot design

**1.2.2 Measurement at the technology park**

**Soil characteristics:** Before planting, soil samples will be taken up and analyzed from to determine soil fertility parameters like nitrogen content (N), potassium exchangeable (K), phosphors extractable (P), organic matter, CEC, Mg, Ca, pH and soil texture parameters like soil sand, clay and silt content (%). The soil horizon thickness (m) and soil density (kg/m3) will also be determined. In 2019, we departed from the idea that all soils in a field are homogenous and then soil sample will be taken at different points in the field and mixed to constitute an average. Soil sampling will be done from 0 to 20 cm and from 20 to 40 cm.

**Crop growth parameters:** The parameters of crop growth that will be collected include: sowing date, emergence date, plant density, plant height, biomass (at different dates), leaf area index (LAI), yield and harvest date. The different dates of plant height, biomass and LAI measurement will also be monitored.

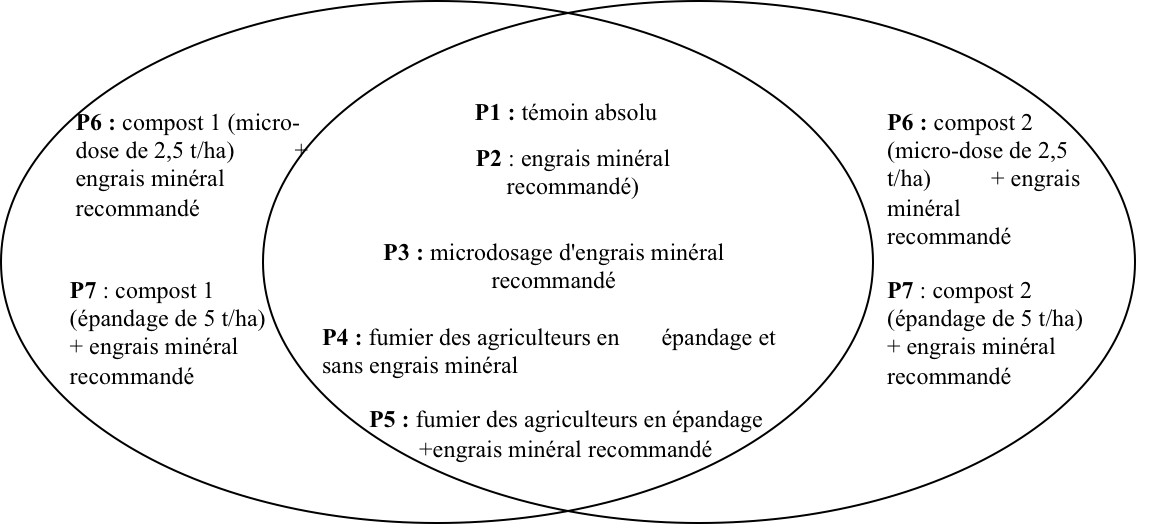
**For soil water content:** Volumetric soil water content will be estimated every ten days during the rainy season. Through soil depth, the measurement will be done at 10 and 20 cm. Soil moisture measurement will start the same date as crop sowing and will continue every 10 days until the end of the rainy season. Block B2 and B3 have been selected for measuring soil moisture. The auger will be used by default for taking soil samples.

**Statistical analysis:** Individual effect of the principal factor will be analyzed followed by the effect of secondary factors. Interaction effects will be also analyzed.

**Farmer field experiment of composting**

In each of the three villages, the experiment will be conducted with the two types of composting as follows.

**Farmer using Compost 1 Farmer using Compost 2**

******

|  |  |
| --- | --- |
| **Farmer using Compost 1** | **Farmer using Compost 2** |
| P1\_Zero (no application of compost and no mineral fertilizer) | P1\_Zero (no application of compost and no mineral fertilizer) |
| P2\_Control practice 1 (100kg/ha of DAP) | P2\_Control practice 1 (100kg/ha of DAP) |
| P3\_Control practice 2 (40kg/ha of DAP by micro-dosing) | P3\_Control practice 2 (40kg/ha of DAP by micro-dosing) |
| P4\_Compost farmers practice without cotton stem 5t/ha by spreading) + (100kg/ha of DAP) | P4\_Compost farmers practice without cotton stem 5t/ha by spreading) + (100kg/ha of DAP) |
| P5 \_Compost farmers practice without cotton stem 2.5 t/ha by micro-dosing) + (100kg/ha DAP) | P5\_Compost farmers practice without cotton stem 2.5 t/ha by micro-dosing) + (100kg/ha DAP) |
| P6\_Compost 1 with cotton stem 2.5 t/ha by micro-dosing + (100kg/ha of DAP) | P6\_Compost 2 with cotton stem 2.5 t/ha by micro-dosing + (100kg/ha of DAP) |
| P7\_Compost 1 with cotton stem 5t/ha by spreading+ (100kg/ha of DAP) | P7\_Compost 2 with cotton stem 5t/ha by spreading+ (100kg/ha of DAP) |

**Experimental design**

Experimental design will be a simple block design whereby each farmer will be considered a replication. Dual-purpose sorghum variety will be used with normal plant density (0.75x0.3). Individual plot size will be 36 m2 (6m x 6m).

**1.3 Objective 3: Exploring and testing intensification option for crop-livestock integration.**

**1.3.1 Method**

The study will be conducted with 6 agro-pastoralists respectively, two per village. Cattle corralling will be done during the dry season in the fields under which experiment will be conducted. For corralling system, 10 cattle will be isolated overnight in an enclosure of 150m2 (15m x 10m) for respectively 3 days, 7 days, 10 days and 15 days. Manure and urine deposit will be quantified.

The enclosure will represent an experimental plot under which three planting density will be conducted. The farmer field will be considered as a control treatment.

**1.3.1.1 Experimental design**

Experimental design will be on simple block design considering each farmer as a replication. Dual-purpose sorghum variety will be used with three planting density (normal plant density: 0.75m x 0.3m; high plant density: 0.75m x 0.20m and low plant density: 0.75m x 0.40m). Individual plot size will be 36m2 (6m x 6m).

**1.3.1.2 Measurements**

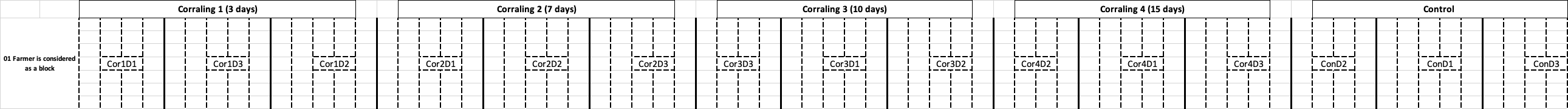
**Soil characteristics:** Before planting soil samples will be taken up and analyzed from laboratory to determine soil fertility parameters like nitrogen content (N), potassium exchangeable (K), phosphors extractible (P) organic matter, CEC, Mg, Ca, pH and soil texture parameters like sand, clay and silt content (%). The soil horizon thickness (m) and soil density (kg/m3) will be also determined.

**Crop growth parameters:** Sowing date, plant density, plant height and biomass at 15, 30, 45 days after planting, yield and biomass at harvest date will be determined.

**1.3.2 Statistical analyses:** Individual effect of the principal factor will be analyzed as well as soil fertility and yield variability across farm types. The interaction effect of fertilizer and planting density will also be analyzed.

**Experimental** (farm field)



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**Sub-activity MA1113-19: Participatory evaluation of dual-purpose sorghum hybrids in Bougouni and Koutiala**

**Lead: ICRISAT: Dr Baloua Nebie**

**1.1 Location**: 4 technology parks of the Africa RISING in Bougouni and Koutiala, Mali. There will be 2 different trials in each zone.

**2.1 Objective**: Assess the socio-environmental suitability and grain & stover yields of dual-purpose sorghum hybrids in Mali

**2.2 Design**

**2.2.1 Genetic material =** 4 new dual-purpose sorghum hybrids selected from 34 varieties evaluated by farmers for grain yield and plant architecture in 3 zones of Mali.

**List of material**

|  |  |  |  |
| --- | --- | --- | --- |
| **Entry** | **ID** | **Pedigree** | **Type** |
| 1 | ICSX 1765505:H | ICSA 176006/Grinkan | New hybrid |
| 2 | ICSX 1765690:H | ICSA 176013/ND07 e21(17x30)F2-6-v | New hybrid |
| 3 | ICSX 1765232:H | ICSA 176003/Grinkan | New hybrid |
| 4 | ICSX 17651145:H | ICSA 176018/ND07 e21(17x30)F2-6-v | New hybrid |
| 5 | Fadda | 12A/Lata | Released hybrid (check) |
| 6 | Local | Local | Local check |

**2.2.2 Experimental design**

In each location, the trial with the 4 sorghum hybrids + 2 checks will be implemented following Fisher blocks design with 3 replications (Figure below, Field layout). The size of the plot is 6 rows of 3 m with 0.75 m between rows and 0.3 m between hills. There will be then a total of 11 hills per plots. Five grains will be sown per hill and thinned at 2 plants per hill 2 weeks after sowing.

**Summary of the physical design:**

Fisher blocks with 3 replications

Number of varieties = 6 to sow 5 grains per hill

Number of rows =6 rows

Length of the row = 3 m

Distance between rows = 0.75m

Number of hills per row = 11

Distance between hills = 0.30 m

Thinning = 2 plants per hill = 2 plants

Distance between bands = 1.5 m

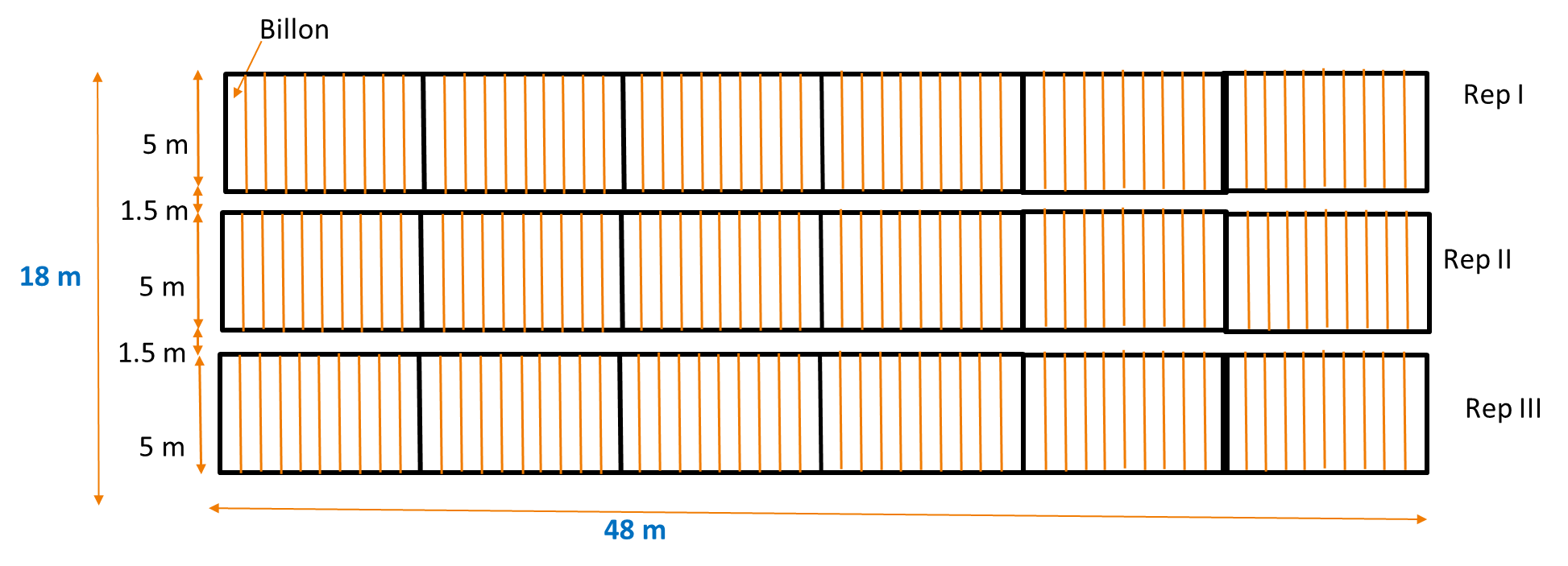


Figure: Field layout

**Fertilizer application:** The recommended rates of fertilizer will be applied: DAP 100 kg/ha two weeks after sowing and 50 kg of urea/ha 40 days after sowing.

**2.2.3 Measurements: Traits to be observed**

|  |  |  |  |
| --- | --- | --- | --- |
| **Trait** | **Abbreviation** | **Description** | **Score/Unit** |
| Seedling vigor | VL | Observe plant vigor, considering the total biomass 14 days after sowing | 1-5 (**5**= Excellent, **1**= very weak) |
| Flowering | 50%FL | Note the date when 50% of the plants in the plot have around half of the panicle presenting anthers (flower) | Date |
| Plant height | HPL | Distance between the soil and the top of the panicle at physiological maturity | Cm |
| Variety appreciation | AV | Farmers look at the variety and say if they would like to grow it. Here the observation must be done for each plot. This observation is done by the group of men and also the group of females and the comments are recorded for each plot at physiological maturity | score 1-5 where 5= off course (excellent), 4= yes (good), 3=ok (can try it) 2= there are some defaults, 1= never |
| Farmers’ preference | FP | At physiological maturity, farmers vote with different color of cards (white = I like the variety and want to grow it in my field, yellow = I want to try the variety but at very small scale and red = variety rejected. Here 3 different preferences are calculated: Men preferences (PrefM), Women preference (PrefW) and the Global preference (PrefG) are calculated | % |
| Number of hills harvested | NPr | Determine the total number of hills harvested on the 4 central rows of each plot at harvesting period | Number |
| Number of panicles harvested | NPAr | Determine the total number of panicles harvested on the 4 central rows of each plot at harvesting period | Number |
| Weight of fresh biomass | BioFT | Weigh the stems + fresh leaves from the 4 central rows of each plot at harvesting period. | Kg |
| Weight of fresh biomass’ sample | BioFE | Take a sample of stover (fill the hand), cut into small pieces, put in a bag of onion (red ones with holes) and weigh fresh | Kg |
| Weight of dry biomass’ sample | BioSE | Dry the bags under the sun for about 2 months and when dry, weigh the contents of the bags and note the weight | Kg |
| Weight of harvested panicles | PPa | Record the weight of all panicles harvested after drying in harvest bags for around 7 days | g |
| Grains weight | PGr | Make threshing in the harvest bags, to reduce the loss of seeds. Then take the weight grains in g | g |

**Observation sheet 1: Agronomic data collectionin Flola technology park (the only difference with the protocols of the 3 other park is the randomization)**

| **Plot** | **Entry** | **Rep** | **Genotype** | **VL** | **50%FL** | **HPL** | **AV** | **PefM** | **PrefW** | **PrefG** | **NPr** | **NPAr** | **BioFT** | **BioFE** | **BioSE** | **PPa** | **PGr** | **Comment\*)** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1001 | 2 | 1 | ICSX 1765690:H |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1002 | 4 | 1 | ICSX 17651145:H |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1003 | 6 | 1 | Local |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1004 | 1 | 1 | ICSX 1765505:H |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1005 | 3 | 1 | ICSX 1765232:H |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1006 | 5 | 1 | Fadda |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2001 | 5 | 2 | Fadda |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2002 | 4 | 2 | ICSX 17651145:H |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2003 | 1 | 2 | ICSX 1765505:H |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2004 | 3 | 2 | ICSX 1765232:H |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2005 | 2 | 2 | ICSX 1765690:H |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2006 | 6 | 2 | Local |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 3001 | 2 | 3 | ICSX 1765690:H |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 3002 | 5 | 3 | Fadda |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 3003 | 3 | 3 | ICSX 1765232:H |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 3004 | 4 | 3 | ICSX 17651145:H |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 3005 | 6 | 3 | Local |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 3006 | 1 | 3 | ICSX 1765505:H |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

**\*)** It is very important to use the comment column to record all observations specific to the plot, for example bird damage at planting time, termite mounds in the plot, difference between plants, damage animals, stagnant water, anything that is not normal, etc.

|  |
| --- |
| 1. Name of the check provided by farmers :\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |
| 2. Reason for choosing this check : \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |
| \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |

**Observation sheet 2 rainfall recording**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Rainfall recording sheet (mm), Location Date: …………………………….Year: …………….** | | | | | | | | | | |
| **Days** | **March** | **April** | **May** | **June** | **July** | **August** | **September** | **October** | **November** |
| 1 |  |  |  |  |  |  |  |  |  |
| 2 |  |  |  |  |  |  |  |  |  |
| 3 |  |  |  |  |  |  |  |  |  |
| 4 |  |  |  |  |  |  |  |  |  |
| 5 |  |  |  |  |  |  |  |  |  |
| 6 |  |  |  |  |  |  |  |  |  |
| 7 |  |  |  |  |  |  |  |  |  |
| 8 |  |  |  |  |  |  |  |  |  |
| 9 |  |  |  |  |  |  |  |  |  |
| 10 |  |  |  |  |  |  |  |  |  |
| **Total decade 1** |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
| 11 |  |  |  |  |  |  |  |  |  |
| 12 |  |  |  |  |  |  |  |  |  |
| 13 |  |  |  |  |  |  |  |  |  |
| 14 |  |  |  |  |  |  |  |  |  |
| 15 |  |  |  |  |  |  |  |  |  |
| 16 |  |  |  |  |  |  |  |  |  |
| 17 |  |  |  |  |  |  |  |  |  |
| 18 |  |  |  |  |  |  |  |  |  |
| 19 |  |  |  |  |  |  |  |  |  |
| 20 |  |  |  |  |  |  |  |  |  |
| **Total decade 2** |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
| 21 |  |  |  |  |  |  |  |  |  |
| 22 |  |  |  |  |  |  |  |  |  |
| 23 |  |  |  |  |  |  |  |  |  |
| 24 |  |  |  |  |  |  |  |  |  |
| 25 |  |  |  |  |  |  |  |  |  |
| 26 |  |  |  |  |  |  |  |  |  |
| 27 |  |  |  |  |  |  |  |  |  |
| 28 |  |  |  |  |  |  |  |  |  |
| 29 |  |  |  |  |  |  |  |  |  |
| 30 |  |  |  |  |  |  |  |  |  |
| 31 |  |  |  |  |  |  |  |  |  |
| **Total decade 3** |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
| **Number of days per month** |  |  |  |  |  |  |  |  |  |
| **Total per month** |  |  |  |  |  |  |  |  |  |
| **Total for the cropping season** |  | | | | | | | | |

**2.3 Data analysis**

Data collected will be first checked and cleaned using Excel. The broad-sense heritability (H2 = VG/VP) will be performed later for each trait and per trial. The trials with low heritability (< 0.20) will not be considered for global analysis. VG = genetic variance and VP = phenotypic variance.

The Analysis of Variance (ANOVA) will be then performed for each trait to compare the different genotypes as well as the environments and the interactions G x E.

The stability of each genotype will be also evaluated using AMMI model.

**Sub-activity MA1114-1901: Identification of varieties of vegetable crop species adapted to Mali under dry season conditions**

**Lead: WorldVeg: Dr Jean-Baptiste Tignegre**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **A.** | **Title:** | | **Sub-activity MA1114-1901: Identification of varieties of vegetable crop species adapted to Mali under dry season conditions** | | | | | | |
| **B.** | **Outcome 1** | | Farmers and farming communities in the project area are practicing more productive, resilient, and profitable and sustainably intensified crop-livestock systems linked to markets. | | | | | | |
| **C.** | **Objectives:** | | 1 Evaluate/ demonstrate new promising vegetable varieties (tomato, onion, African eggplant, pepper, vegetable cowpea) for dry season adaptation using farmer’s participatory variety selection  2. Determine the profitability of vegetables and gender preferred species and variety characteristics in the dry season | | | | | | |
| **D.** | **Experimental Design:** | | | | | | | | |
|  | a) No. of replications: | | | | **Mother trials in the technology parks**: 4 replicates  **Baby trials**: 60 farmers per district   * 5 villages with 12 individual farmers/village * Each farmer is a replicate   Districts: 2 (Bougouni and Koutiala) | | | | |
|  | b) Proposed design:  **1 Technology parks (Mother trials):**  Separate trials will be implemented for each vegetable crop species  **1.1 Experimental plot:** A raised bed of 1 x 5 m2 will be constructed in two technology parks in each district (Koutiala and Bougouni) for nursing onion, pepper, eggplant/vegetable cowpea and tomato seedlings. Dressed seeds will be nursed by drilling at a depth of 2-3 cm and mulched. Watering will be done every other day until 3-4 weeks (40 days for onion) after planting when the seedlings are ready for transplanting. Experimental fields in all intervention communities will be ploughed and harrowed.  **1.2 Experimental design:**  The field layout will beRandomized Block Design (RCD) with 5 treatments (varieties) and 4 replicates.  **1.3 Planting date:** September 2019  **1.4 Cultural practices:**   * **Fertilizer Application:** Basal application of compound fertilizer (NPK, 15-15-15) to both maize and vegetables will be made at rates of 200kg/ha. Topdressing with Sulphate of ammonia (100kg/ha) at 5-6 weeks after planting will follow. * **Weeding:** Hand weeding at 2 weeks after planting will be made and 5 weeks after planting. * **Insect Pest control:** Insect pests will be controlled by spraying Neem oil concentration: *azadirachtine* at 1200 ppm; 10ml/l; Commercial name: Mali-neem   **1.5 Sites:** technology parks in Bougouni and Koutiala (Mali) and/or other partner intervention areas.  **2. Farm field trials (Baby trials):**   * Sites: 2 districts (Koutiala & Bougouni) * 60 farmers per district * Each selected farmer will test 1 replicate of 5 varieties * Each farmer will implement separate trials of 2-3 crop species amongst those listed in the mother trials. | | | | | | | | |
|  | CRD | | | | | SPLIT PLOT | | | |
|  | RBD | | | | | Others (please specify) | | |  |
|  | c) Treatments: | | | | | | | | |
|  | *Single factor:* | | | | | | | | |
|  | Factor Description: | | | Variety | | No. of levels: | | 4 (onion: 6) | |
|  | *Multi-factor*: | | | | | | | | |
|  | Factor Description: | | |  | | No. of levels: | |  | |
|  |  |  | | | |  |  | | |
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|  |  |  | | | |  |  | | |
|  | d) Field Trial: | | | | | | | | |
|  | Total area available (m x m) 1 acre | | | | | Total no. of plots 12 | | | |
|  | Plot size (m x m) 5 x 4 = 20 m2 | | | | | Harvest area per plot (m x m) 10 | | | |
|  | e) Non-field Trial: (Describe experimental procedure --- use extra sheets if needed):  At harvest, organoleptic tests will be organized to enable varieties ranking upon the comparison between varieties within same vegetable species. | | | | | | | | |
| **D.** | **Data Collection** (List all characters to be measured. Describe sampling/measurement techniques)  Data to be collected on vegetables include agronomic characters, disease and pest scoring, post-harvest handling and social surveys: The following parameters will be recorded:  Plant height at 50% flowering, number of leaves/plant, number of fruits/plot and fruit weight (1st, 2nd and 3rd harvest); product cost, input cost, labor cost and income, profit, gender preferred species, varieties and traits. Preliminary identification of diseases will be undertaken based on the symptoms on the plants. Also, samples will be collected, and the identification and characterization of diseases will be done in the laboratory.  Besides, records will be taken on farmer sex, age, wealthiest, farmland GIS position, rainfalls. Three system intensification domains will be covered by data collection:   * Production: Fruit yield (kg/ha), Fodder yield (kg/ha) * Environment: Disease and pest damage scores * Social: Access to land, market & preference for varieties at household level * Economic: Comparative cost/benefit analysis of vegetable species | | | | | | | | |
| **E.** | **Proposed Data Analysis**:  Technology parks:   * Separate trial analysis for each crop species as RBD with 4 replicates using GLM in Genstat program * Over locations and years of trials, analysis to determine variety adaptation or stability   On-farm trials:   * Mother and baby trial analysis: RBD with nb of mother + baby trials as nb of replicates | | | | | | | | |
| **F.** | **Comments and Suggestions**:   |  |  | | --- | --- | |  | **Genetic materials for dry season** | | **Mali** | Tomato (\*Keneya, Rio Grande, Bebiyereye, Local); onion AVON1074, AVON1073, AVON1308, AVON1310, AVON1023, AVON1314, Local); African eggplant (L10, Meguetan, Keur Bin Daw, Local) and vegetable cowpea (IT85S-2805-5, Telma, IT85F-867S-5, IT84S-911, Local) | | | | | | | | | |

**Trial in the technology park**

5m 1m

V1

V4

V5

V3

V2

4m

1m

V3

V2

V1

V5

V2

V5

V4

V3

V1

V4

V3

V5

V4

V2

V1

**District**

District

Village

Farmer

**Sub-activity MA1111-1902: Test and demonstrate vegetable performance using sack gardens to enable more access to vegetables and generate income for women farmers in the rainy season**

**Lead: WorldVeg: Dr Jean-Baptiste Tignegre**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **A.** | **Title:** | | **Sub-activity MA1114-1902:** **Test and demonstrate vegetable performance using sack gardens to enable more access to vegetables and generate income for women farmers in the rainy season (September 2019).** *Leader: Jean-Baptiste Tignegre; Wubetu Legesse, Felix Badolo, Honafing Diarra, Mahamadou Dicko* | | | | | |
| **B.** | **Outcome 1** | | Farmers and farming communities in the project area are practicing more productive, resilient, and profitable and sustainably intensified crop-livestock systems linked to markets. | | | | | |
| **C.** | **Objectives:** | | The deployment of sack gardens aims at enabling vegetable production by women with no access to land or reliable water sources for normal gardening. It involves recycled fertilizer bags as containers filled with soil and compost serving as plant substrate. It promotes space and water use efficiency and a diverse range of legumes species grown in a confined space. Three to four cycles of production are possible annually. In the house, it appears as a source of food and ornamentals. The access is easy for all social categories in rural, urban and peri-urban areas. | | | | | |
| **D.** | **Experimental Design:** | | | | | | | |
|  | a) No. of replications:  **Mother trials in the technology parks**: 4 replicates  **Baby trials**: 60 farmers per district   * 5 villages with 12 individual farmers/village * Each farmer is a replicate   Districts: 2 (Bougouni and Koutiala) | | | | | | | |
|  | b) Proposed design: Hundred farmers in two districts (Bougouni and Koutiala) will test tomato, onion, amaranth, cabbage, carrot, and vegetable cowpea, using 50kg-content recycled fertilizer sacks in the dry season. Fifty farmers in each district will plant 25-30 vegetable seedlings per vegetable species: of amaranth, African eggplant, tomato, cabbage, onion, carrot, and vegetable cowpea on the open top of the sacks (horizontal position).  c) The field design will be randomized blocks with 4 replicates in two technology parks across 2 locations (Bougouni, Koutiala); non-lead farmers will test a single replicate of tomato, Amaranth, African eggplant, onion, cabbage, carrot, vegetable cowpea.  **Planting date:** September 2019 **Insect pest control:** Insect pests will be controlled by spraying Neem oil: *azadirachtine* at 1200 ppm; 10ml/l; Commercial name: Mali-neem; 1 application each other week on leaves, buds, flowers and fruits (Lamini Samake, 2016).  **Sites:** technology parks in Bougouni and Koutiala (Mali)   * 60 farmers per district   Each selected farmer will test 1 replicate of 5 varieties | | | | | | | |
|  | CRD | | | | SPLIT PLOT | | | |
|  | RBD | | | | Others (please specify) | | |  |
|  | d) Treatments: | | | | | | | |
|  | *Single factor:* | | | | | | | |
|  | Factor Description: | | | Variety | No. of levels: | | 60 | |
|  | *Multi-factor*: | | | | | | | |
|  | Factor Description: | | |  | No. of levels: | |  | |
|  |  |  | | |  |  | | |
|  |  |  | | |  |  | | |
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|  |  |  | | |  |  | | |
|  | e) Field Trial: | | | | | | | |
|  | Total area available (m x m) 9 m2 | | | | Total no. of plots 10 | | | |
|  | Plot size (cm x cm) 80 x 50 = 0.4 m2 | | | | Harvest area per plot (m x m) 0.4 m2 | | | |
|  | f) Non-field Trial: (Describe experimental procedure --- use extra sheets if needed):  Food security analysis survey | | | | | | | |
| **D.** | **Data Collection** (List all characters to be measured. Describe sampling/measurement techniques:  Data to be collected on vegetables include agronomic characters, disease and pest scoring, post-harvest handling and social surveys: The following parameters will be recorded: Plant height at 50% flowering, number of leaves/plant, number of fruits/plot and fruit weight (1st, 2nd and 3rd harvest); product cost, input cost, labour cost and income, profit, gender preferred species, varieties and traits. Preliminary identification of diseases will be undertaken based on the symptoms on the plants. Also, samples will be collected, and the identification and characterization of diseases will be done in the laboratory.  Besides, records will be taken on farmer sex, age, wealthiest, farmland GIS position, rainfalls. Three system intensification domains will be covered by data collection:   * Production: Fruit Yield (kg/ha), Fodder yield (kg/ha) * Environment: Disease and pest damage scores at plot level (% damage by disease or pest/organ/ variety/plot) * Social: Capacity to experiment, gender preferred species or varieties characteristics * Economic: Comparative cost/benefit analysis of vegetable species | | | | | | | |
| **E.** | **Proposed Data Analysis**:  On-farm trials:   * Mother and baby trial analysis: RBD with number of mother + baby trials as number of replicates * Over locations and years of trials analysis to determine variety adaptation or stability | | | | | | | |
| **F.** | **Comments and Suggestions**:   |  |  | | --- | --- | |  | **Genetic materials for humid season** | | **Mali** | Amaranth (Aziga), African eggplant (L10), tomato (Keneya: high vitamin A containing tomato); cabbage, onion (AVON1074), carrot and vegetable cowpea (IT85S-2805-5) | | | | | | | | |

**Sub-activity MA1121-19: Efficient feed utilization through improved feed troughs**

**Lead: ILRI: DR Augustine Ayantunde**

**1.1 Justification**

Improved feed troughs for small ruminants and cattle were designed based on the specifications from Africa RISING Ethiopia and were demonstrated in M’Pessoba, Sirakele and Zanzoni in Koutiala district involving 45 farmers between August 2018 and April 2019. Preliminary results from data collected showed that the improved feed troughs reduced feed waste significantly by about 10%. The farmers confirmed that the improved feed troughs led to a reduction in feed waste. The results in Ghana also showed that farmers spent about 10 minutes/day less time on feeding the animals but the results in Mali did not show any difference in time spent on feeding the animals using the traditional and improved feed troughs. The data collection was only conducted in the late dry season and it is necessary to monitor the use of the improved feed troughs across different seasons (wet, early dry and late dry seasons) to have a correct assessment of the benefit of the technology. Also, the cost of the improved feed troughs for cattle and small ruminants is currently high around 350 and 250 USD for cattle and small ruminants, respectively. Using the locally available construction materials may significantly reduce the cost of the improved feed troughs and will facilitate easier and quicker adoption by the farmers. This sub-activity, therefore, aims at building on the demonstration of the improved feed troughs by collecting additional data on the use across seasons and at the same time monitor the adoption by the farmers within and outside the intervention communities.

**1.2 Objective and hypothesis**

The objectives of this sub-activity are: (i) To assess the effect of season on feed utilization and manure production using the improved feed troughs in the 2 regions in northern Ghana (Northern and Upper East regions). (ii) To monitor the adoption of the improved feed troughs within and outside the intervention communities. (iii) To evaluate the potential for use of local materials for the construction of the improved feed troughs including cost and benefit analysis. (iv) To assess the effect of additional modifications (feed trough height, shade, storage options and watering points) on overall feed intake, avoided feed wastage and labor savings based on different gender groups. The underlying hypothesis for this sub-activity is that improved feed troughs lead to efficient feed utilization and that seasons affect the quantity of feed that could be saved through improved feed troughs.

**1.3 Study sites**

This study will be conducted in M’Pessoba, Sirakele and Zanzoni in Koutiala district between August 2019 and March 2020.

**1.4 Number of farmers to be reached**

Sixty farmers including the forty-five farmers involved in the demonstration of the use of the improved feed troughs in M’Pessoba, Sirakele and Zanzoni in Koutiala district will be involved in this study.

**1.5 Method of data collection**

The participating farmers will be monitored in the wet and early dry seasons over six days consecutively to collect data on feed offered and the leftovers, and time spent feeding the animals using the improved feed troughs compared to the traditional feed troughs. Also, manure collected from the animals fed using the traditional and improved feed troughs will be measured in each season during the 6 days of the data collection. To assess the potential of reducing the cost of the improved feed troughs, another five farmers will be selected randomly in each intervention community to build feed troughs with local materials. The design of the improved feed troughs with locally available materials will follow the same specifications provided by Africa RISING Ethiopia. Data will also be collected on the use of the feed troughs built with the local materials. Data to be collected will be similar as for the improved feed troughs that had already been constructed. The amount of time spent in looking after the animals while feeding (bringing back dispersed feed, keeping animals to feed comfortably) will be recorded for both improved feed troughs and traditional feeding practices. A survey questionnaire will be administered to all participating farmers to document their opinions about the contribution of the technology and its acceptance. A simple cost-benefit analysis of the improved feed troughs made with local materials will be conducted. Samples of the feed offered, and the left-overs will be analyzed to assess quality for both improved feed troughs and traditional feeding practice. A survey on the adoption of the technology within and outside the intervention communities will be conducted to characterize the adopters and non-adopters, and the drivers of adoption.

**1.6 Frequency of measurements**

Six days consecutively each in wet and early dry seasons.

**1.7 Data analysis**

Data to be collected will be analyzed with SAS using frequency, means and analysis of variance procedures.

**1.8 Link to the data collection template or survey instrument**

Not yet available

**Sub-activity MA1122-19: Fodder production for improved ruminant productivity**

**Lead: ILRI: Dr Augustine Ayantunde**

**1. Justification**

Feed scarcity is one of the major constraints to ruminant production in Mali. There is a great potential to bridge the feed gap in smallholder mixed crop and livestock systems through the introduction of forage species in southern Mali given the annual rainfall of about 900 mm spread over 5 to 6 months. Under the USAID Mali Livestock Technology Scaling Program there has been demonstration of the potential of a few forage species as livestock feed, for example *Brachiaria ruziziensi* and the results look promising from the biomass produced. However, adoption has been limited. To promote adoption of the forage species, the establishment of demonstration plots at the Technology Park will expose many farmers to this technology and will provide an opportunity for learning on how to plant the fodder species.

**2. Objective and hypothesis**

The objectives of this sub-activity are: (i) To demonstrate the potential of forage species in bridging feed gap in smallholder mixed crop and livestock systems in southern Mali. (ii). To promote the adoption of forage species for improved ruminant productivity. (ii) To build the capacity of farmers in forage production. The underlying hypothesis for this sub-activity is that improved fodder production increases livestock productivity and enhances household income of smallholder and crop and livestock farmers.

**3. Study sites**

This demonstration on fodder production will be conducted at the Technology Park in Koutiala and Bougouni districts between August 2019 and March 2020.

**4. Number of farmers to be reached**

At least 100 farmers will visit the demonstration plots of the improved fodder at the Technology Park in Koutiala and Bougouni districts.

**5. Method of data collection**

Fodder species namely *Brachiaria ruziziensis*, *Lablab purpureus* and *Sorghum almum* will be planted in the Technology Park in one community per region to demonstrate the potential of fodder production for improved ruminant production and to build the capacity of the farmers. A plot each measuring 50m2 (10 x 5m) will be established at the Technology Park in Koutiala and Bougouni for each fodder species. Agronomic data such as germination rate, plant height, leaf area index, and total biomass will be collected. Farmers will also be trained on how to plant the fodder species and on fodder production. The training will be conducted by an expert in forage agronomy including basic principles for improved fodder production and practical demonstration at the Technology Park. The demonstration plots will be shown to farmers during the annual Africa RISING project farmers’ field day to promote adoption of the forage species by farmers. Farmers’ feedback on the performance of the different forage species and the willingness of farmers to grow *Brachiaria* in their farm in the next season will be collected.

**6. Data analysis**

Data to be collected will be analyzed with SAS using means and analysis of variance procedures.

**MA1131-19: Risk management and informed decision making towards sustainable intensification of crop-livestock systems**

**Lead: WUR: Dr Katrien Descheemaeker**

**1. Objective 2.1: To explore the future impacts of sustainable intensification pathways in different SI domains (productivity, economic, environmental, human well-being) through scenario analysis and discuss these with local stakeholders**

**1.1 Selection of indicators**

Indicators were selected based on a hierarchical framework linking principles or domains with criteria and indicators, as described by Florin *et al*. (2014)[[73]](#footnote-74) and Marinus (2018)[[74]](#footnote-75) (Table 1).

Table 1: List of all indicators and causal links to the scenarios

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Domain** | **Criteria** | **Causal links to the scenarios** | **Indicator** | **Unit** |
| Productivity | Increased farm productivity | … can affect the crop and livestock production and thereby the amount of self-produced biological inputs | Self-produced fodder | kg year-1 |
| Self-produced manure | kg year-1 |
| … increases the cropping and livestock production | Legumes production | kg year-1 |
| Cereals production | kg year-1 |
| Cotton production | kg year-1 |
| Animal production | kg milk year-1 |
| Economic | Reduced poverty | … enhance on farm production and enable off-farm revenue streams which result in increased remittances | Income per capita | $PPP capita-1 day-1 |
| … affect crop and livestock production and labor requirements | Labor productivity | $PPP/man-day |
| Environmental | Improved soil fertility | … change the nitrogen application and farming practices | Nitrogen balance | Kg |
| Improved resource use efficiency | … implement new farming techniques | Nitrogen use efficiency | ratio |
| Humanwell**-**being | Enhanced human health | … will affect income and food production | Nutritional self-sufficiency | ratio |
| Labor intensity | ratio |

PPP: purchasing power parity

**1.2 Extension of the scenario analysis**

The existing scenarios are adapted to capture the effects on all selected indicators (i.e. going beyond food self-sufficiency and income), based on literature and analysis of policy, economic and farm management trends in Mali.

**1.3 Dataset**

Farm characteristics datasets from 99 households in Nampossela and 312 households in Sirakélé were combined. The data was collected by CMDT in 2013. Based on crop area (ha), the number of workers, herd size and the number of draught tools the farms were classified in four different farm types following the typology of Falconnier *et al*. (2015). The distribution of the different farm types was 10 %, 21 %, 52 % and 17 % for HRE-LH, HRE, MRE and LRE farms respectively in Nampossela and 9 %, 22 %, 58 % and 11 % in Sirakélé.

**1.4 Model simulation and data analysis**

A simple model (Figure 1) is run for all households in the database for the baseline situation and the future scenarios. The model calculates the performance of every household according to all the indicators. Farm performance is compared between different types and different scenarios using averages and the coefficient of variation to understand variability. Trade-offs are explored based on radar charts.

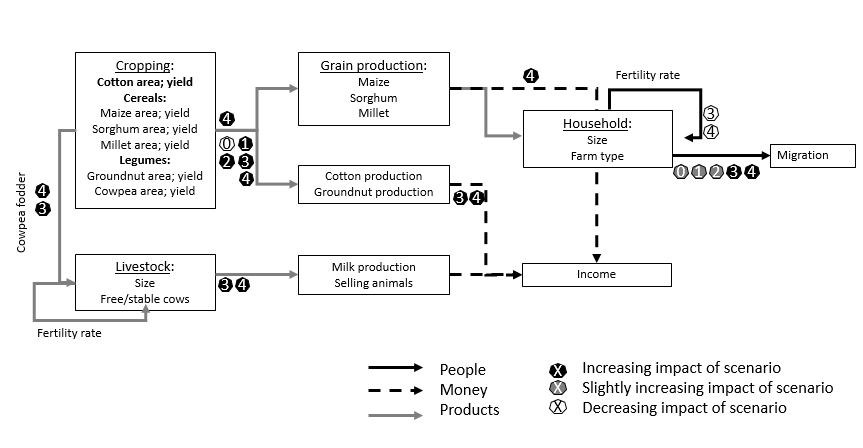


Figure 1: Simple model of a typical farm household from the Koutiala region and the different flows of people, money and products between the main household components independent from farm type (Falconnier *et al*., 2018). A hexagon indicates that a scenario described by the number in the hexagon has a direct impact on the flow. The colour of the hexagon describes the nature of the effect on the scenario.

**1.5 Stakeholder workshop**

A stakeholder workshop will be organized in February-March 2020. A group of about 20 stakeholders will be invited for a one-day workshop to discuss the results of the scenario analysis. Stakeholders will include farmer representatives, NGO actors, extension service representatives, private actors, local policymakers. The workshop will aim to disseminate the results and receive feedback on the scenarios and the findings, which will be used to further adapt the scenario analysis. The results of the scenario analysis will also feed into a visioning exercise, in which the group of stakeholders will work towards carving out a shared vision for farming systems in southern Mali.

**2.1 Objective 2.2: To assess the potential of crop-livestock and SI interventions in terms of risk mitigation in relation to for example weather and market shocks and uncertainty**

**2.2. Objectives:**

1. To quantify the effect of shocks on-farm production (for different farm types)
2. To explore the effects of risk mitigation strategies on-farm production stability (for different farm types)

**2.3 Input data (already available)**

1. List of most important hazards perceived by farmers based on analysis of risk focus group discussions and surveys in 2017 and 2018 (250 household members form 58 farms). The same farms were asked for the risk management strategies they already apply.
2. Long term weather data from N’Tarla weather station (1965-2011)
3. Market prices of different agricultural products from project collection or secondary data (e.g. Observatoire du Marche Agricole (OMA))
4. Farm typology based on resource endowment developed by Falconnier et al. (2015)
5. Farm characteristics (household composition, livestock and crop management practices, available resources) based on RHoMIS survey held in 2018 with 78 farmers (<https://www.rhomis.org/>).
6. Selection of SI options that seemed promising in the on-farm trials as part of a co-learning cycle between farmers and researchers from 2012-2019.

**2.4 Model and software**

1. For the effects on crop production the crop growth model DSSAT will be used for maize, millet, sorghum and groundnut (<https://dssat.net/>).
2. Data management, analysis and visualisation will be done using R

**2.5 Methodology**

* Calibration of DSSAT to the local environmental conditions, using previously defined parameters for crop varieties, soil and weather conditions relevant for the Koutiala region (by project partners, e.g. Adam et al., 2018).
* Selection of most important hazards to include in the analysis
* Selection of risk management strategies and SI options to include in analysis
* Selection of management rules based on literature and agronomic on-farm experiments. For example, when draught power is limited due to animal sickness (hazard), how does this impact the farms’ draught power and thus the timeliness of important farm operations such as sowing and weeding.
* Further development of the model set-up for a whole-farm analysis, integrating the field-level simulation results.
* Analysis and simulation of SI options and other risk management strategies in scenarios of shocks.

**2. 6 Output indicators (minimum, depends on selection of hazards/scenarios as well)**

* Crop yields
* Farm income
* Farm food self-sufficiency

**2.7 Feedback sessions**

The results of the desktop analysis will be shared and discussed with farmers during focus group discussions in 2020, in the four villages where the initial risk FGD’s were held (Table 1). These FGD will feed information back to farmers and will contribute to the scientific discussion by learning from farmers’ feedback.

**Table 1. The suggested number of farmers per villages to invite for the feedback sessions**

We will focus on the farmers (HH heads) that participated in the risk survey in 2018. The number of farmers is stratified according to their type (HRE-LH: High Resource Endowed-Large Herd, HRE: High Resource Endowed, MRE: Medium Resource Endowed, LRE: Low Resource Endowed). The most extreme types are less present in the village.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Village | Number of farmers | *HRE-LH* | *HRE* | *MRE* | *LRE* |
| Deresso | 17 | *2* | *6* | *6* | *3* |
| N’Tiesso | 19 | *2* | *7* | *9* | *1* |
| Nampossela | 11 | *2* | *3* | *4* | *2* |
| M’Peresso | 12 | *3* | *4* | *4* | *1* |
| Total | 59 | *9* | *20* | *23* | *7* |

**3. Objective 2.3. To develop, test and adapt a decision support tool for farm planning and budgeting with farmers in southern Mali**

**3.1 Context**

Farm in southern Mali, similar to family farms worldwide, combine two interrelated units, namely the farm as a unit of production and the household as a unit of consumption. The decisions on the two units are mutually interrelated, and therefore a decision support tool targeted to farmers should take into account this aspect, that consumption needs and patterns may have a strong impact on crop allocations. In the cotton-based systems of Koutiala, the cycle of agricultural production is annual and usually stars in June and ends in May, while the yearly consumption of crop harvests starts in January. Furthermore, the overall agricultural production is divided into two seasons, namely, the rainy season (June to December 2019) and the dry season (January to May 2020), while the consumption is considered in one single season (Table 1).

Table 1:Chronogram of annual cycles of production and consumption of cotton systems in Mali. The green color indicates the current use of harvests realized from the previous rainy season, while the blue indicates the future use of harvests being realized currently

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Production of crops during the seasons | | Consumption of crop’s harvests from the dry and rainy seasons for: | | | | | |
| Food (i.e Jan-Dec) | | Fodder (i.e. Jan-Jun) | | Income (i.e. Jan-Dec) | |
| 2019 | 2020 | 2019 | 2020 | 2019 | 2020 |
| Dry season (i.e. Jan-Mai) | 2019 |  |  |  |  |  |  |
| 2020 |  |  |  |  |  |  |
| Rainy season (i.e. Jun-Dec) | 2018 |  |  |  |  |  |  |
| 2019 |  |  |  |  |  |  |
| 2020 |  |  |  |  |  |  |

**3.2 Objective**

To develop, test and adapt a decision support tool for farm planning, budgeting, monitoring and evaluation of cropping activities in southern Mali.

**Specific objectives**

1. Elaborate and test a tool for discussion with the farmer that can be used by the extension agents to analyse the situation of a farm;
2. Elaborate and test a planning and budgeting tool of farming activities, which also helps to have information on the intended plan of farmers before the rainy season starts;
3. Elaborate and test a monitoring tool of farming activities, which also helps to have information throughout the rainy season about activities implemented and operations performed;
4. Elaborate and test an ex-post assessment tool of farming activities, which may help farmers to adjust their decisions on objectives formulated regarding the amount of production achieved.

**3.3 Activities**

The research is being conducted in two villages of the cotton-based systems of Koutiala, namely Nampossela and N’Tiesso. In the current agricultural season of 2019, 11 farmers per village are testing the tools. The selection of farmers took into account the four farm types distinguished in the local context (Falconnier *et al.*, 2015)[[75]](#footnote-76). Two farmers are selected per farm type and in addition, three literate people were selected who can help the other farmers to use the tool if need be.

The activities to implement for the adaptation of the tool are displayed, below, in figure 1. The different elements of the tool were elaborated in April 2019. After that, in May 2019, we applied the tool with farmers to diagnosis the current farm situation and suggest sustainable options for improvement. At the same time, we planned and budgeted farming activities, by taking into account the farmers’ objectives for food, fodder and income in 2020, as well as expected key expenditures. During the season, the farmers use the monitoring tools to keep records on the activities and cropping operations performed. In January 2020, after all the crops are harvested and the yields are known, farmers will use the evaluation tool for assessing the achievements, which will help them to properly plan activities to implement throughout the dry season (i.e. January to May 2020), as well as to plan for the household consumption over the year.

**3.4 Data collection**

Data is being collected at all moments when the different tool components are used with and by farmers. This generates information on the 22 testing farmers, regarding their farming activities and the resulting performance of the various farm components. A field agent passes by all the farmers every two weeks for checking and updating the available information on operations realized throughout the rainy season.

**3.5 Data cleaning and analysis**

Quantitative data collected will be typed and harmonized in an Excel document, while qualitative data, such as the testimonies of farmers, will be saved in a word document. Statistics will be performed using R. The analysis will make use of both the quantitative and qualitative data.

**Figure 1: Steps followed for adapting the farm management tools**

**Sub-activity MA 1211-19: Determination of cropping management factors using empirical relations, GIS and Remote Sensing tools in two agro-ecologies of Mali**

**Lead: ICRISAT: Dr Mirja Michalscheck**

**1. Justification**

The semi-arid region of Mali is characterized by intensive agriculture, land degradation and very strong climate variability. In that agro-ecological zone, soil-water erosion is a major problem and monitoring this type of erosion becomes necessary to secure sustainable soil water management. Water erosion is mainly caused by water running off the fields. It is important to note that often the process of water erosion and water infiltration into the soil, particularly at the landscape level, has not been well understood by scientists and farmers.

Plant available nutrients are concentrated in the topsoil and losing that layer due to water erosion causes a drop of inherent soil fertility levels of N, P, K, and thus to a decline in potential crop yield. The productivity of eroded soils can be restored by adding inputs if favorable subsoil material is present. This will increase the amount of manure and fertilizer to be supplied and compensate the crop nutrients needed. Using manure and fertilizer cannot restore productivity loss when subsoil materials are unfavorable (physical and chemical properties) for plant root growth. It is difficult to restore soil fertility by adding inputs where fragile subsoils, limited rooting depth, coarse sand and gravel or high densities are dominant.

Furthermore, the importance of controlling soil erosion is not restricted to the maintenance of the productive potential and fertility of soils; but is also an effective means to ensure employment in the rural villages and reduce excessive rural exodus and poverty. Therefore, efficient erosion control is very advantageous from the ecological and social perspectives, besides being highly significant from an economic point of view.

Soil erosion reduces the presence of plant-available water, soil organic matter, and water and nutrient use efficiencies. To predict plants behavior and monitoring the fertility, information on the spatial distribution of plant nutrients is essential. To preserve water and soil resources, stakeholders need information on landscape-level natural resources to plan suitable strategies and measures. The mapping of soil erosion risks identifies vulnerable areas for environmental protection. In addition, the economic value of soil erosion can be used by the decision-makers to prioritize areas of soil water conservation.

**2. Objectives**

The objectives of this activity are: (i) Determine crop management factors using empirical relations, GIS and Remote Sensing tools in two agro-ecologies of Mali. (ii) Assess the impact of soil erosion on landscape soils productivity. (iii) Evaluate variations of plant-available nutrients, such as carbon, nitrogen, phosphorous, and potassium in different agro-ecologies under different land-use systems. (iv) Identify areas affected by natural and anthropogenic changes. (V) Provide appropriate guidance and recommendation on environmental protection to help increase crop productivity and reduce soil degradation.

**3. Study sites:** This study will be conducted at landscape level for the two districts of Bougouni and Koutiala, southern Mali.

**4. Data collection**

Existing data on soil moisture, climatic data, soil properties, and geographic coordinates of the study sites will be sourced from Africa RISING phase I reports and data archives. New data sets to be collected include Landsat satellite images, NDVI, DEM, and survey data. Ground-based soil moisture data will be calibrated with landscape soil moisture data obtained from remotely sensed images to investigate the influence of landscape-level runoff generation and status of soil water infiltration. The rainfall amount and intensity will be used for calculating the rainfall erosivity factor. The topographic map and Digital Elevation Map from high-resolution satellite data will be used to calculate the soils topographic factor and the soil erodibility factor using the universal soil loss equation based on geographic information system (GIS). Mapping of cropping management factors will be based on land use data at landscape scale. Ground truthing will be made using GPS (Global Positioning System) for the verification of different classes of land use and it will be used in mapping and verification of the model outputs. These maps will be used to identify vulnerable areas or erosion hot spots areas at landscape level. A survey will be organized to investigate farmers’ perception of the influence of landscape level soil water erosions on smallholder income and the contribution of erosion to poverty and outward migration.

**5. Methods**

1. **Erosion and Infiltration:**

The data in CBT and NCBT will be used in statistical software (R, SPSS) to determine the impact of CB on water infiltration in six different layers (100 mm, 200 mm, 300 mm, 400 mm, 600 mm and 1000 mm). This result will be used to produce a map of the impact of CB on soil moisture variation at different levels.

1. **Soil erosion**

Landscape-level soil erosion will be determined using an empirical relation of the Modified Universal Soil Loss Equation (MUSLE) and prediction of soil loss from agricultural lands due to rill and sheet erosion will be made. MUSLE is a function of rainfall pattern, soil type, topography, land use and land management practices.

1. ***Rainfall Erosivity Factor (R):***

The calculation of this factor is be based on annual mean rainfall by using Analyst Tools (which interpolates a raster surface from points using an inverse distance weight technique (IDW)) in GIS software (ARCGIS). This will be collected from the meteorological stations in the two districts. The equation of Nguyen, 1996 will be used in Raster Calculator tool for the estimation of the rainfall erosivity factor.

1. ***Soil Erodibility Factor (K):***

This factor is related to the physical and hydraulic of soil properties. The soil properties include antecedent moisture, porosity, surface roughness, texture, and aggregation. Soils’ vulnerability to erosion is determined by K factor, the higher the K value is, and the higher the erodibility is. K depends on stability of soil structure, soil texture, and soil organic matter; in this study, K values will be determined based on the value of soil texture. The available data on soil texture will be used for soil mapping.

1. ***Topographic Factor (LS):***

The slope length factor L computes the effect of slope length on erosion, and the slope steepness factor computes the effect of slope steepness on erosion. Slope (*S*) and slope length (*L*) values will be calculated from DEM by using Spatial Analyst Tools in GIS software (ArcGIS).

1. ***Cropping Management Factor (C):***

The C factor depends on vegetative cover and the cropping management practices. Vegetation cover reduces soil erosion potential because the vegetation cover protects and leads to slowing down surface runoff movement and enhancing surplus surface water infiltration. The land use/cover map will be made based on satellite images using ArcGIS software.

1. ***Conservation Practices Factor (P)****:*

The Pfactor map will be constructed by combining the land use map and the slope map. The land use map will be converted to raster map. The Raster Calculator Tool in ArcGIS will be used to calculate the *P* value map by combining the land use type value and the slope value.

1. **soil erosion and soil productivity**

Soil erosion is harmful to productivity of soil. Soil nutrients data collected from the different areas will be subject to statistical analysis to determine the impact of soil erosion on its productivity using R software.

1. **Environmental vulnerability**

In this study, the satellite data and ground truth data will be used for land use/cover classes and topographic sheets. Land cover classes will be typically mapped from digital remotely sensed data using supervised, digital image classification.

1. **Change detection**

Land use/cover change detection describes changes in the two satellite images for the same area in different periods (1990, 2000, 2010 and 2018). Each Landsat image will be classified using supervised classification and the accuracy assessment will be done at each image classified. Images classified will be compared from one to another for the determination of different land use/land cover changes using GIS tools.

1. **Thematic maps**

Thematic maps of geology, geomorphology, soil, vegetation and land use/cover will be prepared from satellite images (Landsat, Sentinel-2, Modis) in ArcGIS. Band ratios will be used to make geology map. Soil data analysis in the laboratory will be used to validate satellite data for soil mapping. Vegetation and land use/land cover will be made through supervised images classification base on ground truth data. Each map will be compared with sheets from “*Institut Géographique du Mali (IGM*)” respectively.

1. **Economic model**

An economic model which is built using mathematical programming will be used to assess the economic value of soil erosion by water. The comparison between the baseline scenario (without erosion) and alternative scenarios where the soil erosion risk is incorporated will be analyzed to show the total income of the watershed reduction with the effect of soil erosion. This model will be combined with the environmental model for the determination of erosion on soil loss. The basic model can be written as:

Constraints

Subject to

Where: Z is the objective function to be optimized, C is objective function coefficients, X is vector of decision variables, A is the matrix of technical coefficients, b is a vector of constraint coefficients.

**Protocol - Sub-activity MA1212-19: Improving crop-livestock productivity and household income through the use of contour bunding and agroforestry options**

**Lead: IER: Dr Kalifa Traore**

**1. Justification**

Mali is one of the countries in the Sudano-Sahelian zone of West Africa where the general decline in soil fertility is a major constraint to agricultural productivity (Kouyaté *et al*., 2000[[76]](#footnote-77)). Rather than increasing soil productivity, current farmer practices such as hoe tillage, ridges tillage, conventional tillage, and no or insufficient application of amendments continue to mine the soil nutrients. Yields of crops obtained by the application of low doses of manures and mineral fertilizers have led to continuous depletion of soil nutrients.

In recent years, both drought or inappropriate rain distribution and demographic pressures have put enormous strain on the natural environment of Kani and Noupinesso. Tree and grass cover have dwindled, with disastrous consequences for the soil, which is left bare to the erosive winds and rains of the tropics. Soil erosion and farming activities that extract nutrients from the soil have caused severe soil degradation in these villages, threatening food and animal feed security. Although, the region receives substantial rainfall, yet much is lost during intense storms on soils with low infiltration rates.

Efforts to address these problems have been directed at assessing the impact of tillage, leguminous plant, and soil amendments on soil and water conservation and crop yield and of particular importance is the use of contour bunding technology (CB) in crop cultivation system. Contour bunding is a holistic landscape approach to manage water and capture rainfall on a watershed scale (Gigou *et al*., 2006[[77]](#footnote-78)). It is a technology developed locally by the Institut d‘Economie Rurale (IER) and CIRAD (Gigou *et al*., 2006). Doumbia *et al*. (2009)[[78]](#footnote-79) reported that CB retains rainfall and improves water availability for crops and enhances soil carbon sequestration. According to him it increased deep drainage and groundwater recharge and increased soil organic concentration after 3 years. Traoré *et al*. (2002)[[79]](#footnote-80) summarized the expected beneﬁts of the CB on soil carbon to include the following: (1) reduced erosion losses of soil and residue C, (2) increased growth of trees and crop, especially those that annually shed their leaves, (3) increased crop yields due to increased soil moisture, and (4) forage and building material from grasses that stabilize permanent ridges and waterways.

Julio and Carlos (1999)[[80]](#footnote-81) indicated that in Mali the agriculture soils are characterized by low land productivity associated with poor rainfall, low soil fertility, and traditional crop management practices. The judicious use of manure, mineral fertilizer and leguminous plant may be a credible option for improving soil fertility and crop yield. For the agronomic and economic performance of soil fertilization in Kani and Noupinesso the using of micro-dosing is indeed needed for the production of food and cash crops. However, the beneficial effects of the combined use of mineral fertilizers, and manure (compost and farmers’ animal manure) under different tillage practices have received less research attention. Yet such studies are needed to yield the requisite baseline information for introducing leguminous plant, micro-dosing and CB technology into the farming system of smallholder farmers. It is in this context that this study was carried out.

**2. Objectives:**

a. General objective:

Improving crop and livestock productivity and household income through the use of contour bunding technology (CBT) and agroforestry options

b. Specific objectives:

* Implement nursery for planting fast-growing trees species on the crest of contour bunds
* Collect farmers demanding CBT and Implementation of demonstration plots
* Evaluate crops and fodder plants growth and yields under CBT
* Evaluate the effect of micro-dosing system on crops yield
* Determine the efficiency of intercropping of sorghum and soybean

**3. Research questions**

* Does fodder plant provide environmental and livestock interest?
* What is the impact of CB on fodder trees production?
* Does micro-dosing technology improve crops yield and farmer’s income in comparison with recommended doses of fertilizers?
* What is the impact of intercropping of leguminous crop and sorghum when combined with CBT?

**4. Expected Outcome and Knowledge Contribution in line with key Africa RISING Framework**

1. Contour bunding technology (CBT) protects farmland from degradation   
   • CBT is a technology that reduces runoff and soil erosion while increasing moisture in the soil profile and consequently increase crops and associated trees yields  
   • Micro-dosing system increase crops yields and profitability
2. Intercropping system of cereal and leguminous increase soil N and intercropped cereal’s yield
3. Improving crops and forage productivity lead to improve the nutrition quality of farmers and their animals
4. Grouping of farmers at the beginning of the study to discuss the activities and their importance, grouping of all demanding farmers of CB technology, and organization of training for sustainability can reinforce farmer’ social cohesion

**5. Measuring the Outcomes**

* CBT on soil properties are assessed  
  • CBT on crop and forage yields are determined  
  • CBT technology is adopted in the study area  
  • The effects of micro-dosing on crop yield are evaluated
* The profitability of the intercropping system is evaluated   
  • Economic profitability of CB and micro-dosing is assessed in the study area

**6. Link with Design Principles**

**6.1 Study area**

The study will be carried out at Kani, Noupinesso, and Mpessoba in Koutiala district. The village of Kani is located in the rural district of Nafanga (Karangasso), Koutiala region. It is distant from the paved road Koutiala Koury (RN12) of 5 km after 45 km from Koutiala. The Latitude 12° 14' 43.23'' North and the longitude 5° 10' 57.94'' West with an elevation of 384 m in Koutiala region. It is located in the East by Noumpinesso (Yorosso circle), in the West by Karangasso, in the North by Zébala and in the South by Soukoumba.

**6.2 Methodology**

6.2.1 Soil preparation (Implementation of CBT)

The automatic level and a graduated staff allowed us to determine and materialize the contour line using stakes implemented at a regular distance.

A field visit with each farmer allowed us to identify the water circulation routes and the problems of erosion or flooding that occurred, the fields made in CB technology varied from one (1) to three (3) ha per farmer. The implementation of the contour line started 25 m away from the field upper limit. On the contour lines, a stake was placed every ten (10) meters to materialize it using 3 to 4 passes- return of an oxen plow to make an earth bund of 1 m wide called “Ados”. The distance between the ados was about fifty (50) meters. The rows of seedlings or the ridges followed these ados for a good functioning of the arrangement and the ados were reinforced with a dabas. Spontaneous grasses were usually allowed to grow on the ados and fodder plants were planted on two ados in each field. In 2018 before the rain season we executed with farmers the maintenance of the ados.

6.2.2 Setting up of trials

6.2.2.1 Experimental Design

Two types of experiments conducted:

1. For the first, a trial was a factorial combination of two tillage practices (Contour bunding CB technology and no contour bunding NCB or farmer’s practices) and (four types of soil fertilization)
2. Soil fertilization**:**

* No amendment
* Organic manure OM (5t ha-1)
* Micro-dose = OM (2.5t ha-1) + Complex cotton CC (100 kg ha-1) + Urea (25 kg ha-1)
* Recommended dose = OM (5t ha-1) + Complex cotton CC (200 kg ha-1) + Urea (50 kg ha-1)

The trial is in split-plot design with four replications: tillage practices will be conducted on the main plots with the soil amendments as subplots. The dimensions of the subplots are 4 x 3m. The main plots are separated by 1m wide access using cotton (Gossypium sp) N’TA 93- 15 as test crop. The same trial will be conducted on six different farms (three at Kani and three at Noupinesso).

* The second trial also is a factorial combination of two tillage practices (CB and NCB) and (three farming systems: Sorghum sole crop, intercropping sorghum-soybean, soybean sole crop)

This trial follows the split-plot design with four replications: tillage practices conducted the main plots with the farming systems as subplots. The dimensions of the subplots were 10 x 5m. The main plots were separated by 1m wide access using sorghum (Sorghum bicolor L. Moench) negnebling (90-100 days) and soybean (Glycine max (L.) Merr.) G115 (110 days); as test crop, the variety of sorghum for Mpessoba was Bentoroko. The same trial is conducted on nine different farms (four at Kani; four at Noupinesso, and one in the Technology Park of Mpessoba).

Amendments used in intercropping:

Sorghum: OM (2.5 t ha-1) + Complex cereal CC (50 kg ha-1) + Urea (25 kg ha-1)

Soybean: OM (2.5 t ha-1) + DAP (50 kg ha-1)

**6.3 Maintenance of trials:**

Crop weeding was done 15 days and 30 days after seedling, the earthing up was carried out 40 days after seedling ended the last weeding was done 15 days after. Growth and development (height, diameter, number of capsules), grain yield, crop biomass yield were determined on the center lines of the elementary plots.

Forty collaborative farmers will be chosen in two villages because this number is what is feasible with accurate data according to the experiment type. Before implementation, soil sampling will be performed using an auger at 0-20 cm and 20-40 cm depth and samples send for physicochemical analysis in the Soil-Water - Plant Laboratory of IER. The field of each farmer will be divided into two parts. The first part is under contour bunding (CB) i.e. ridges follow contour lines and the second one with farmer’s practices labeled as non-contour bunding (NCB) implemented as a control. The contour lines will be planted with fast-growing tree species chosen by farmers, such as *Gliricidia sepium* and *Leucaena leucocephala*. Tree species will be planted on the crest of the contour bund which will be 0.8 m width and 100 m length. The distance between the tree species will be 3 m. In each part, trials based on cotton or sorghum intercropped with soybean will be implemented. In each trial only the inputs (fertilizer, pesticides) will be supplied by researchers, all the other factors (crop species, varieties, tillage technique, maintenance etc.) will be those of farmers.

**6.4 Data to be collected and uploaded on Dataverse:**

1. Biophysical data: height, basal diameter, crown radius and diameter at 1.3 m height when possible) will be performed on fast-growing trees species starting at their plantation date.
2. Cultural operations: Plowing or ridging date, planting date, emergence date, thinning date, planting density, plant density at harvest, plant height, grain yield, straw yield, thousand grain weights.
3. Soil physical and chemical properties
4. Crop yield (straw and grain)

**6.5 Calculations**

6.5 1 Land Equivalent Ratio (LER)

The performance of crop intercropping is generally evaluated by:

• Grain yield, biomass yield

• Quality (protein content, etc.)

• The LER = Land Equivalent Ratio

The LER assesses crop-intercropping efficiency during its development cycle. It compares the yields of crop associated with the yields of crop alone. The LER is the area of monospecific cultures required to achieve the same yield as in combination. It is calculated as follows:

If LER = 1, there is no difference between the two culture modes;

If LER < 1, there is a loss of yield in association;

If LER > 1, or there is productive advantage with the intercropping system (PerfCom, 2012).

6.5.1 Value to cost ratio (VCR)

The unsubsidized input costs and the crop peak prices were used to calculate the VCR as a first indicator of acceptability of investment, using the formula of Nziguheba et al. (2010):

RVC

Where Y is the value of the crop in intervention plots, Yc is the value of the crop harvested in control plots, and X is the cost of inputs (seeds and fertilizers).

Statistical analysis

Data is subjected to analysis of variance using GENSTAT version 12 (GenStat Release 12.1 (PC/Windows Vista) Copyright (2009), VSN International Ltd) and significant means are separated with least significant difference (Lsd) at 5%. Some data was analyzed using the EXCEL software for intermediate and graphical calculations

6.5.2 Total N

Total N in the straw and grain samples are used to calculate N use efficiency (NUE) and its component traits according to an expanded model of Moll *et al*. (1982)[[81]](#footnote-82).



Where, Ntf (kg ha-1) = total aboveground N content at maturity of fertilized treatment, Ntc (kg ha-1) = total above-ground N content at maturity of control treatment, Ns (kg ha-1) = N supplied.

Fodder plants:

Fodder plants will be raised in the nursery. The *Leucaena leucocephala* seeds will be soaked in boiled water for two (2) days and seeds of *Gliricidia sepium* in non-boiled water for two (2) days as well. Sowing will be done at the rate of one grain per pot.

The nursery was watered two (2) times daily (morning and evening) and treated with Furadan 5G every fifteen (15) days from 07/04/2017 until 22/05/2017, corresponding to four (4) times before the transplanting. This took place in the cotton belt where farmers are predominantly cotton farmers and receive regular trainings on pesticide handling and safety precautions from cotton companies. The transplanting date was from 15 to 20/07/2017. The seedlings were transported by motorcycles in wooden crates from the nursery to the field. The seedlings were planted on the contour bunds in the CB fields and field edges in the NCB fields. The planting holes were 20 cm in diameter and 30 cm in depth. Dead transplanted seedlings were replaced about fifteen (15) days later (from 28-30 July 2017). At the end of the rainy season, the end of October, growth and development of these fodder plants (height, diameter at base, diameter at 1.30 m, and crown radius) were determined every 15 days until 30 May 2018.

**Protocol MA1221-19: Improved irrigation technologies for efficient and sustainable agricultural water management in rural Mali**

**Lead: ICRISAT: Dr Zemadim Birhanu**

**1. Justification**

In rainfed agricultural systems, sustainable and efficient water management practices are key to improved agricultural productivity and natural resources management. The agricultural productivity in sub-Saharan Africa (SSA) heavily relies on the availability of rainfall. With the erratic and unreliable rainfall and poor and fragile soils, the crop and livestock productivity remain low over the years in most of SSA countries including Mali. Much of the SSA agricultural land has been degraded and is less fertile as a result of continuous years of cultivation and being prone to wind and water erosion. This results in less production and increased food shortages because the population is increasing. Agricultural and nutritional securities are further hampered by lack of reliable access to the available water resources in the subsurface.

This sub-activity aims at improving agricultural productivity, nutritional security and household incomes through the use of solar energy pumps and improved irrigation technologies for efficient and sustainable agricultural water management in rural Mali. Similar to other SSA countries neither hydrocarbon energized motor pumps nor electrical pumps are affordable by the smallholder farmers in rural Mali. Introduction of solar energy-based irrigation pumps are ideal for increasing agricultural productivity and diversifying farming practices to produce high valued agricultural products like meat and vegetables. Solar panels are becoming more affordable and the improved solar photovoltaic (PV) technologies, with low carbon footprint, have been identified as high potential solutions for rural electrification as well as for water extraction for domestic, livestock and irrigation purposes in SSA. As such, solar PV pumps and improved irrigation technologies have become an emerging climate-smart technology in SSA for smallholder farmers. To be highly effective the solar irrigation technologies need to be accompanied by improved agronomic management practices and soil moisture conservation techniques.

**2. Objectives**

The objectives of this study are: (i) to evaluate existing initiatives and constraints in using efficient and sustainable water management practices using solar energy pumps and improved irrigation technologies, (ii) to identify public-private partnership through multi-stakeholder approaches to avail and promote solar energy pumps and improved irrigation technologies to smallholder farmers, (iii) to conduct a multi-criteria GIS framework to map potential agricultural water management investment areas based on climate, topography and aquifer characteristics, (iv) to develop an appropriate and affordable methodology in using solar irrigation technologies along with improved agronomic management and soil moisture conservation technologies

**3. Study sites**

This study will cover the nine villages (four in Bougouni and five in Koutiala) of Africa RISING intervention areas. The first two objectives (i & ii) will be conducted during the 2019/2020 period and the findings and outputs will be utilized to achieve the objectives stated in (iiii & iv) in the year 2020/2021.

**4. Method of data collection**

The work utilizes survey data information on existing initiatives and practices of utilizing solar energy-based pumps and improved irrigation practices in Koutiala and Bougouni. This activity is done in the current season of the AR program and its output will help to design solutions for agricultural water management investment options for the smallholder farming communities. GIS and Remote Sensing technologies along with climate information (e.g., radiation, number of sunshine hours etc.) will be employed to characterize and define suitable zones to implement solar-based energy pumps. Efficient water management solutions will be accompanied with other technologies (improved crop cultivars, soil and water conservation practices and agronomic packages) to evaluate the gains in productivity, environment, economic, social, and human well-being of the sustainability options. These data should be collected in each of the following domains:

a) Productivity:

Yield and fodder (kg/ha/season) at plot level. Farmer perceptions and ratings of technology yield performance as the result of the technologies at household level

b) Environment:

# days during the growing season without adequate soil moisture (from rain or irrigation) for crop growth at farm level. Farm level: Depth to shallow groundwater. Household: # months without adequate supply of clean drinking water (within 500m), Farmer perceptions of water availability. Landscape level: % hh with year-round access to drinking water, % of livestock farmers with year-round access to water, % of irrigable land (given current investment) with sufficient irrigation water, % of streamflow not diverted for agriculture or drinking water. % of water sources (wells, streams) with clean water, % of population with year-round clean drinking water.

c) Economic:

Net returns per unit labor input, land input, capital input, at plot level

% of production sold (by crop, animal product), % of land allocated to cash crops at farm level. % of total income from agriculture, % of total consumption from own production at household level.

d) Social:

Variability and distributions of productivity, income and assets at landscape level

Active farmer groups, active innovation platforms, % of community members participating in some form of social group, # of conflicts over resources. Presence of formal agreements for resource sharing at landscape level

e) Human:

Market supply of diverse food, Infrastructure (e.g. warehousing, access to markets/roads, irrigation; dependent on geography), Number of farmers experimenting the technology at landscape level

**5. Methods of analysis**

The survey data will be coded and then subjected to statistical analysis tools (R, SPSS). Descriptive statistics and analysis of variance procedures will be applied to the data. The results from the analysis will be used in GIS tools to map suitable areas for intervention and appropriate approaches to be used.

The answers from these questions will be used to study existing solar pump irrigation systems in southern Mali using the five sustainable intensification options.

Questionnaire Number…No………………. District………………………………

Village/Community……………………..Lat ……………… Long……………

Date of Interview………/…./20

1. **Demographic and basic information about solar pump**
2. Sex M F
3. Age of respondent…………….
4. Education: No formal education Primary Secondary Tertiary others…
5. What is the household Size?
6. Do you use solar energy pump?

Yes No

1. If yes, for what purpose you use solar pump?

i. Domestic ii. Livestock iii. Irrigation iv. All

1. If No,
2. Why?

i. Lack of finance ii. Lack of awareness iii. No need iv. Other reason

1. Do you still consider the importance of using solar panel? Yes No
2. If yes, for what purpose?

i. Domestic ii. Livestock iii. Irrigation iv. All

1. If No, why?
2. What is the size under irrigated field? ha
3. What is the water source used for irrigation?

Natural (River) Shallow well Deep-well

1. When (which year) was the solar irrigation system established?
2. What is the approximate rate of water abstraction per hour?
3. What solar power irrigation system or technique is used?

Sprinkler Furrow Micro-sprinkler Drip irrigation Center pivot Other

1. What time of the year do you use irrigation?

Dry season Rainy season Both

1. **Environmental domain**
2. What is the depth of water source used for irrigation?

Natural (River) Shallow well Deep-well

1. What is the amount of water quantity supplied to crops per day?
2. What crops or vegetables do you cultivated using irrigation? Rank them by importance?

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1 | 2 | 3 | 4 | 5 |
| 6 | 7 | 8 | 9 | 10 |

1. What quantity of water (liter per day) do you supply for each crop/vegetable?

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Crops |  |  |  |  |  |  |  |  |
| Water quantity (liter per day) |  |  |  |  |  |  |  |  |

1. What interval of period do you irrigate for different crops/vegetable (insert crops growth)?

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Crops |  |  |  |  |  |  |  |  |  |
| Time (days) |  |  |  |  |  |  |  |  |  |

1. For how long the soil become dry after irrigated?

a. 1-day b. 2-days c. 3-days d. 4-days e. 5-days f. more number of days

1. Do you have insects here? Yes No
2. What type/amount of pest prevention product do you use?

a. Pesticides b. Herbicides

1. Is the water from the solar pump used for drinking? Yes No
2. Do you have enough supply of water throughout the year for?:
3. Drinking Yes No
4. Livestock Yes No
5. Irrigation Yes No
6. **Productivity domain**
7. What is the quantity of yield per season from different crop/vegetable using the solar energy pump?

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Crop |  |  |  |  |  |  |  |  |
| Yield kg/ha/season |  |  |  |  |  |  |  |  |

1. What is the quantity of Stover from different crop/vegetable?

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Crop |  |  |  |  |  |  |  |  |
| Folder kg/ha/season |  |  |  |  |  |  |  |  |

1. What is the Stover used for?

Animal feed Compost Housing Other…………

1. How many times do you cultivate in a year using solar irrigation pump?

a. One b. Two Other…………….

1. How do you rate your crop/vegetable production using solar irrigation system as compared with traditional rainfed system?

a. Excellent b. Very good c. Good d. Bad

1. How do you rate the yield performance of different crops/vegetables using the solar energy system? Rank crops based on the yield gains.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1 | 2 | 3 | 4 | 5 |
| 6 | 7 | 8 | 9 | 10 |

1. **Economic domain**
2. How much investment (CFA) took the construction of the irrigation system? (this refers to the capital input cost in the SI).
3. How much is the cost of the land used for irrigation system? (this refers to the land input in the SI).
4. Who in the household work in the irrigation system?

Head of the house Spouse Children All

1. Do you contract other people to work in the irrigation system? Yes No

If yes, how much do you pay per /day?

1. How many persons work in the irrigated area?
2. For how many hours do they work per day?
3. How many days do they work per week?
4. What is the salary of one person per day/month?
5. What percentage of farmland is allocated for the production of crops/vegetables for cash income?

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Crop/vegetable |  |  |  |  |  |  |  |  |  |
| % of land allocation |  |  |  |  |  |  |  |  |  |

1. What percentage of production sold per crop/vegetable per season?

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Crop/vegetable |  |  |  |  |  |  |  |  |
| % Sell of crop per season |  |  |  |  |  |  |  |  |

1. What amount in CFA you get from each of the crop/vegetable growth per season?

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Crop |  |  |  |  |  |  |  |  |
| Income per season |  |  |  |  |  |  |  |  |

1. What percentage of your agricultural income comes from using solar irrigation pumps?
2. 5% b. 10% c. 20% d. 30% e. 40% f. 50% g. >50%
3. **Human domain**
4. Do you produce diverse crops for home consumption and sale? (nutrition)
5. Yes b. No

v

v

1. Is enough infrastructure available for the production and sale of diverse crops using solar energy pumps?

Yes b. No

v

v

1. Is there enough skill in using solar irrigation systems?

Yes b. No

v

v

1. How much weight animals gain by providing the Stover from irrigated area?
2. How many animals can be fed from a Stover of 1ha and for how long?

v

1. What is the consumption of the production from irrigated area?

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Family member | Adult male | Adult female | Youth male | Youth female | Male children | Female children |
| Consumption% |  |  |  |  |  |  |

1. Is the production from irrigated areas affected by pest and diseases?

Yes No

v

1. **Social domain**
2. Who is the owner of the land irrigated in the family?

Head of Household Spouse Joint Rented

1. How many female workers in the field?
2. Who controls the income from the irrigated field?

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Crop/vegetable | Head | Spouse | Joint | Youth male | Youth female |
| 1. |  |  |  |  |  |
| 2. |  |  |  |  |  |

1. Who decides the amount of sale?

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Crop | Head | Spouse | Joint | Youth male | Youth female |
|  |  |  |  |  |  |

1. Who takes the production to the market?

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Crop | Head | Spouse | Joint | Youth male | Youth female |
|  |  |  |  |  |  |

**Sub-activity MA2221-19: Reduce vegetable postharvest losses through dissemination of Zero Energy Cool Chamber (ZECC) and processing of vegetables and capacity building in dry season**

**Lead: WorldVeg: Edoh Ognakossan Kukom**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Title:** | | **Sub-activity MA2221: Reduce vegetable postharvest losses through dissemination of Zero Energy Cool Chamber (ZECC) and processing of vegetables and capacity building in dry season**  ***Leader: Edoh Ognakossan Kukom****, Wubetu Legesse, Mahamadou Dicko* | | | | | | |
| **B.** | **Outcome 2** | | More farmers and farm families are adopting technologies and practices to improve nutrition, food and feed safety, post-harvest handling and value addition. | | | | | | |
| **C.** | **Objectives:** | | *(This sub-activity was not part of the workplan last year but needs to be implemented since it was ranked amongst top constraints to achieve the output).*  Vegetables are best stored in a cool and humid environment to prevent rotting and dehydration due to their high perishability nature. However, in rural areas farmers mainly store their harvested vegetables at ambient conditions leading to heavy post-harvest losses and loss of income due to lack or unaffordability of electricity to have cooling facilities. Moreover, limited occurrence of market days in such conditions forces farmers to sell off their products. A simple technology such as ZECC which creates cooling conditions without electric power can, however, best be recommended in the above-mentioned context to reduce postharvest losses of vegetables. | | | | | | |
| **D.** | **Experimental Design:** | | | | | | | | |
|  | a) No. of replications: | | | | Randomized block design with 4 blocks (each technology park being a block) | | | | |
|  | b) Proposed design:  The genetic material (tomato, African eggplant and vegetable cowpea) used in sub-activity MA1114-1902 will serve as products for post-harvest tests and demonstrations. The field experiment layout on ZECC in will be RBD with 4 replications and four treatments: Vegetable stored in ZECC (T1), Vegetable mixed with shea butter wood ash (1:2 w/w) and stored in ZECC (T2), Vegetable mixed with shea butter wood ash (1:2 w/w) and stored in ambient conditions (T3) and Vegetable without any treatment and stored in ambient conditions (T4). Each technology park will be considered as a block. | | | | | | | | |
|  | CRD | | | | | SPLIT PLOT | | | |
|  | RBD | | | | | Others (please specify) | | |  |
|  | c) Treatments: | | | | | | | | |
|  | *Single factor:* | | | | | | | | |
|  | Factor Description: | | | Treatment: 5 storage conditions | | No. of levels: | | 4 | |
|  | *Multi-factor*: | | | | | | | | |
|  | Factor Description: | | |  | | No. of levels: | |  | |
|  |  |  | | | |  |  | | |
|  |  |  | | | |  |  | | |
|  |  |  | | | |  |  | | |
|  |  |  | | | |  |  | | |
|  | d) Field Trial: | | | | | | | | |
|  | Total area available (m x m) 2 ha | | | | | Total no. of plots: N/A | | | |
|  | Plot size (m x m) = | | | | | Harvest area per plot (m x m) | | | |
|  | e) Non-field Trial: (Describe experimental procedure --- use extra sheets if needed):  Tomato fruits which will be used for the experiment will be harvested at turning stage while African egg-plant and cowpea pods which will be used will be harvested at recommended maturity stage. The leaves of the vegetable cowpea will also be stored. Tomatoes and African egg-plant fruits will be monitored at 3-day interval over two week’s period. Cowpea vegetable leaves will be monitored daily. The set-up day of the experiment will be considered as day 0. | | | | | | | | |
| **D.** | **Data Collection** (List all characters to be measured. Describe sampling/measurement techniques:  Data on temperature and relative humidity inside ZECC or in ambient conditions, shelf-life, weight loss, quality parameters (color, TSS, acidity) will be measured. For the drying experiment, data on drying rate, moisture content of the products (m.c) as well as color will be recorded. | | | | | | | | |
| **E.** | **Proposed Data Analysis**:  Trial analysis : RBD with 4 treatments and 4 replicates | | | | | | | | |
| **F.** | **Comments and Suggestions**:   |  |  | | --- | --- | |  | **Genetic materials for humid season** | | **Mali** | African eggplant (L10), tomato (Keneya); and vegetable cowpea (IT85S-2805-5) | | | | | | | | | |

**Sub-activity MA4311-19: Title: Evaluation of the effect of the implementation of community local conventions for natural resource management in southern Mali**

**Lead: ILRI: Dr Augustine Ayantunde**

**1. Justification**

Local conventions governing natural resource management in the rural communities, including Africa RISING intervention communities, are largely oral. AMEDD and ILRI, therefore, facilitated the documentation, validation, development and formalization of the local conventions in 3 communities namely Dieba, Sirakele and Zanzoni in southern Mali in 2016. In addition, livestock corridors in each village territory were demarcated and a surveillance committee was established in each community for the implementation of the local conventions. There was positive feedback from the communities in 2016 shortly after the commencement of the implementation of the local conventions. The external review team for Africa RISING included the success story of the local conventions in their report particularly in reducing conflict over natural resource use. It is now about 3 years since the implementation of the local conventions began and it is necessary to evaluate the present effect on natural resource management and the conflict over natural resources use. The video on the elaboration of the local conventions in Zanzoni is on YouTube for more details. <https://www.youtube.com/watch?v=UskGMIkG6_0>.

**2. Objective and Hypothesis**

The objectives of this sub-activity are: (i) To assess the current state of the implementation of the formalized local conventions on natural resource management in three intervention communities, that is, what is working well and what is not working. (ii) To evaluate the effect of the implementation of the local on natural resource management and conflict over natural resource use. The underlying hypothesis for this sub-activity is that elaboration and formalization of oral local conventions enhance better management of natural resources in the communities thereby reducing conflict over natural resource use.

**3. Study sites**

This study will be conducted in Dieba in Bougouni district, Sirakele and Zanzoni in Koutiala district where Africa RISING project had facilitated the elaboration and formalization of local conventions governing natural resource management. The study will be conducted between October 2019 and March 2020.

**4. Number of farmers to be reached**

Given that the elaborated and formalized local conventions in the 3 Africa RISING intervention communities are at community level, the number of farmers to be reached is at least 500 farmers.

**5. Method of Data collection**

Group discussion and individual interviews will be conducted to document the perceived effect of the implementation of the local conventions on natural resource management and conflict over natural resource use in the three intervention communities (Dieba, Sirakele and Zanzoni). Members of the surveillance committee in each community for the enforcement of the local conventions will be interviewed on the state of the implementation of the local resource institutions. At least 30 individuals stratified by gender will be interviewed in each community on their perceived effects of the local conventions. The local government officials will also be interviewed on the challenges and opportunities through the implementation of the local conventions. Cases of conflict before and after the implementation of the local conventions will also be documented.

**6. Frequency of measurements**

This will be a onetime group discussion and individual interview which will likely be conducted in November/December 2019.

**7. Data analysis**

Data to be collected will be analyzed with SAS using frequency and means procedures

**8. Link to data collection template or survey instrument**

Not yet available

**MA4312-19**: **Assess the impact of Innovation Platforms on SI technology uptake in interventions communities of Mali**

**Lead: AMEDD: Bougouna Sogoba**

**1. Objectives**

1. To assess the impact of Innovation Platforms on farmers’ access to information and SI technology uptake
2. To set up and conduct multi-stakeholder platforms and meetings to increase farmers’ particularly women, youth and extension workers’ awareness on SI innovations
3. To improve adoption of SI innovation in intervention communities through advanced co-learning and exposure to validated technologies /innovations

**2. Methodology:**

A participative approach using qualitative and quantitative data will be adopted for this study.

**Data collection:** the required data for the study will be collected with the following tools

**Desk review:** a desk review of existing documents on IP creation and facilitation of IPs during the first phase of the project will be done to have a thorough understanding of the IPs and their functioning in the intervention communities.

**Focus group discussion:** a focus group discussion will be used to collect data on the platform number of members, the diversity and composition of members, the decision-making process, the issues tackled by platform, the funding available, the role of women and men in the platform, the type of capacity building /training received and what are constraints.

**Individual Interview:** individual interviews will be addressed to all members of the innovation platforms at district and communal level. Three tools will be used to assess the perception of innovations platforms by the stakeholders engaged in the process, the level of interactions between stakeholder and the most significant changes operated through the innovation platforms.

**Data analysis:** the collected data will be analyzed with SPSS. The scoring will be analyzed using à Likert-Scale

* **INNOVATION PLATFORM FOCUS GROUP INTERVIEW GUIDE**

**Region: District: Commune:**

**Name of the platform: Type: District/\_\_/ Commune/\_\_/**

**Interviewer: Phone:**

**Interview: beginning \_\_\_\_h\_\_\_mn End: \_\_\_\_h\_\_\_\_\_**

* What is the name of your platform?
* When the platform was set up
* Who created/Setup the platform
* How many members constitute the platform?
* Composition and diversity

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Member | Organization |  | Sex | | Total |
| Women | Men |
|  |  |  |  |  |  |

* What are the objectives of the platform?
* What are the particular issues tackled by the platform?
* What are the roles of female members in the platform
* What are the roles of male members in the platform
* Has the platform dealt with a particular women farmers’ problem?
* How was this particular issue solved?
* Has the platform dealt with a particular men farmers’ problem?
* How was this particular issue solved?
* Did you get access to any innovation through this platform?
* Which one? How has this innovation helped you? Your organization? Your community?
* Did you have access to any capacity building opportunity through the IPS? Which one?
* Which constraints/challenges did you face regarding the Innovation Platform?
* What are the solutions proposed regarding these constraints and challenges?
* **IP MEMBER EVALUATION TOOLS**

**Region: District: Commune: Village:**

**Name of IP: Name of assessor:**

**Name of the respondent: Sex: Age:**

**Date:**

|  |  |  |
| --- | --- | --- |
| **Questions** | **On a score of 0–5, 5 being the maximum, what score would you give the IP concerning:** | **Comments or reasons for the score** |
| Your level of awareness and understanding of the critical issue  being addressed by the IP |  |  |
| Extent to which these issues are relevant for you or how important is it for you to address the issue |  |  |
| How well was the IP facilitation done? |  |  |
| How well the IP meetings and activities were organized |  |  |
| How participatory the activities or discussions were |  |  |
| Whether and how information is sharing within the IP |  |  |
| Extent to which you have felt involved or engaged in the activities of the IP |  |  |
| Were there any conflicts experienced in the IP? |  |  |
| Conflict resolution strategies used within the IP |  |  |
| Extent to which you were involved in contributing to the decisions and design of the research |  |  |
| Extent to which the research done was useful for you |  |  |
| Whether the plans of the IP have been clearly articulated |  |  |
| Extent to which the goals have been achieved |  |  |
| Extent to which you think the IP activities are well coordinated |  |  |
| Extent to which you think the IP activities have dealt with issues pertinent to women farmer |  |  |
| Extent to which you think the IP activities have dealt with issues pertinent to men farmer |  |  |

* **STAKEHOLDER INTERACTION TOOL**

**Region: District: Commune: Village:**

**Name of IP: Name of assessor:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Name of stakeholder | Full name of your organization | Other individuals, organizations you are working with | Type of organization (community-based organizations, farmer organizations, research, NGO, Government department, input dealers, traders, etc.) | Type of activities you are involved in jointly |
|  |  |  |  |  |
|  |  |  |  |  |

**D-Most Significant Change**

**Region: District: Commune: Village:**

**Name of IP: Name of Stakeholder Group:**

**Name of assessor: Date:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Domain of change** | **MSC at IP actor level** | **MSC at IP level** | **MSC at Africa RISING level** | **MSC at community level** |
|  |  |  |  |  |

**Appendices**

**1**.**GH1211-19: Assessing the buffer and adaptive capacity to harness the resilience of different farm types: Interview tool nutritional resilience**Interview template by: Dorien JansenVersion: 2019\_11\_7

**Intro**

|  |
| --- |
| This survey is commissioned by Africa RISING. We would like to discuss the nutritional self-sufficiency and resilience of the household. Following from the interview from yesterday with my colleague we investigate what happens to the diet of the household provided by the farm once a shock or multiple shocks take place. In order to anticipate on these shocks we would like to know from you how you perceive risks and how you would want to see a future version of your farm. Clarification of the questions is always possible. The results are confidential and will only be used for research purposes. Your participation is voluntary. This survey will take about 30 minutes. Do you agree to participate? |

**Basic**

|  |  |
| --- | --- |
| Region: | Name of respondent: |
| Community: | House ID |
| Date: | Personal details (Sex, Age): |
| Duration of the interview (min): | Household type: |
| Name of the enumerator: | *Notes:* |
| Education level (none/low/high): |  |

**Current**

|  |
| --- |
| Whom does your household consist of? *Who have to be fed from the farm (income)?*  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  How satisfied are you with the quantity of the diet of the household as a whole? *Meaning how much there is to eat*  Very unsatisfied Very satisfied  (1) (2) (3) (4) (5)  Which food gives good health?  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  Are the following things, necessary for a quality diet, on a regular basis present in the diet of your household?  Cereals (yes/no)  White tubers and roots (yes/no)  Vegetables (yes/no)  Fruit (yes/no)  Meat (yes/no)  Eggs (yes/no)  Fish and/or other sea food (yes/no)  Legumes, nuts and seeds (yes/no)  Milk and milk products (yes/no)  Oils and fats (yes/no)  How satisfied are you with the quality of the diet of the household as a whole? *Meaning how diverse the consumed food products are and whether everything for a healthy life is present in the diet.*  Very unsatisfied Very satisfied  (1) (2) (3) (4) (5)  If applicable: what do you miss?  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  What do you think is more contributing to a healthy diet: the amount of food or the type of food:  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  Are there pregnant women in the household? (yes/no)  Are there any women breast feeding? (yes/no)  If yes, do these women consume foods that are good for the milk production? (yes/no)  Do you feel the quantity and quality of your diet are the same as for the other household members or or are there differences? *Differences between men/women youth/elderly*  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  Are there seasonal differences in the quality and quantity of the diet? *In the wet season (Jun-Oct), the early dry season (Nov-Jan) and the late dry season (Feb-May).*  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  How often do children younger than three years old fall ill/have diarrhoea? *(never, sometimes, often, very often)*  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  What percentage of produced animal products is yearly used for self-consumption by the household? \_\_\_\_\_\_\_\_\_\_ %  What percentage of produced crop products is yearly used for self-consumption by the household? \_\_\_\_\_\_\_\_\_\_ %  How large is your farm? \_\_\_\_\_\_\_\_\_\_ acres  What is the main reason you are cultivating the crops you have on your farm? *(good nutrition, with those crops I make money, it’s an insurance for the future, other)*  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  What is the main reason you are rearing the animals you have on your farm? *(good nutrition, with those animals I make money, it’s an insurance for the future, other)*  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  How do you perceive your nutritional situation in a normal year? *With 5.5 as just sufficient*  Bad Excellent  (1) (2) (3) (4) (5) (6) (7) (8) (9) (10)  When only taking into account the food products you produce yourself; how would you perceive your nutritional situation in a normal year?  Bad Excellent  (1) (2) (3) (4) (5) (6) (7) (8) (9) (10)  How do you compare the nutritional situation of your household to the other households in the community?  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |

Survey ID:

**Threats**

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| What kind of shock are you most afraid of regarding nutrition? Why?  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  (What happens on farm level when a drought shock occurs?What decisions are taken?)  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  (What happens on farm level when a price shock occurs? What decisions are taken?)  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  How do you perceive your nutritional situation in a dry year? A dry year means 4 weeks of no rainfall during the growing season  Bad Excellent  (1) (2) (3) (4) (5) (6) (7) (8) (9) (10)  And how would you perceive this only taking into account the own produced foods?  Bad Excellent  (1) (2) (3) (4) (5) (6) (7) (8) (9) (10)  How do you perceive your nutritional situation the year after a dry year?  Bad Excellent  (1) (2) (3) (4) (5) (6) (7) (8) (9) (10)  And how would you perceive this only taking into account the own produced foods?  Bad Excellent  (1) (2) (3) (4) (5) (6) (7) (8) (9) (10)  How do you perceive your nutritional situation in a year with very low selling prices? Very low selling prices means -50 % of the price for maize and also -20% for millet, -20% for rice, -20% for yam and -20% for cassava.  Bad Excellent  (1) (2) (3) (4) (5) (6) (7) (8) (9) (10)  And how would you perceive this only taking into account the own produced foods?  Bad Excellent  (1) (2) (3) (4) (5) (6) (7) (8) (9) (10)  How do you perceive your nutritional situation the year after a year with very low selling prices?  Bad Excellent  (1) (2) (3) (4) (5) (6) (7) (8) (9) (10)  And how would you perceive this only taking into account the own produced foods?  Bad Excellent  (1) (2) (3) (4) (5) (6) (7) (8) (9) (10)  What effects do you see the year after a dry year on:  Economic situation  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  Labour requirements  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  Soil quality  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  What effects do you see the year after a year with very low selling prices on  Economic situation  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  Labour requirements  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  Soil quality  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |

Survey ID:

**Dreams**

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| What would you like to improve most concerning the diet of the household?  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  What restricts you from doing/achieving this?  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  Would you rather produce or buy most of your food? Why?  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |

**Options and restrictions**

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| What is the amount of income from farming you and your household want to make yearly?  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  What is the **minimum** amount of income from farming you have to make yearly? To cover up school expenses e.g.)  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  Are there possibilities to work off-farm for the different household members? Is this an attractive option for you?  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  Is hiring labour an option for you and your household? Why (not)?  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  Do you have the possibility to expand your farm to more land? How much? \_\_\_\_\_\_\_\_\_\_\_ acres  How much would this cost you?  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  Do you want to expand your farm to more land?  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  What is your maximum number of different crops you want to grow on your farm?  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |

**Timepath**

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| *Taking into account you’ll have the same amount of labour and the same amount of profit. The changes are all starting from the 2019 situation.*  How many new crop species introductions are you willing to make in one year? \_\_\_\_\_\_\_\_\_\_\_ species  On what area? \_\_\_\_\_\_\_\_\_\_\_ % of the farm  How many new crop species introductions are you willing to make in three years? \_\_\_\_\_\_\_\_\_\_\_ species  On what area? \_\_\_\_\_\_\_\_\_\_\_ % of the farm  How many new crop species introductions are you willing to make in five years? \_\_\_\_\_\_\_\_\_\_\_ species  On what area? \_\_\_\_\_\_\_\_\_\_\_ % of the farm  What is a realistic type and number of animals to buy in one year?  Type \_\_\_\_\_\_\_\_\_\_\_  Amount \_\_\_\_\_\_\_\_\_\_\_  What is a realistic type and amount of animals to buy in three years?  Type \_\_\_\_\_\_\_\_\_\_\_  Amount \_\_\_\_\_\_\_\_\_\_\_  What is a realistic type and amount of animals to buy in five years?  Type \_\_\_\_\_\_\_\_\_\_\_  Amount \_\_\_\_\_\_\_\_\_\_\_  Are you aware of the Africa RISING practices in this community? (yes/no)  *If not talk about the packages that aim at an improved cultivation and a better integration of maize, cowpea and soybean within local farm systems and the feed and health intervention. Baby and upscale trails. Baby is 15x15. Upscale is 0.45ha-0.45ha.*  How many Africa RISING practices would you want to adopt in one year? \_\_\_\_\_\_\_\_\_\_\_ practices  On what area? \_\_\_\_\_\_\_\_\_\_\_ % of the farm  How many Africa RISING practices would you want to adopt in three year? \_\_\_\_\_\_\_\_\_\_\_ practices  On what area? \_\_\_\_\_\_\_\_\_\_\_ % of the farm  How many Africa RISING practices would you want to adopt in five year? \_\_\_\_\_\_\_\_\_\_\_ practices  On what area? \_\_\_\_\_\_\_\_\_\_\_ % of the farm |

Thank you very much for your participation! Do you have any question(s) to us?

**2. Behind the models**

**GH1211-19: Assessing the buffer and adaptive capacity to harness the resilience of different farm types**

**2a. Modelling the disturbances**.

Adapted tables from Michalscheck et al. (2020, in prep.)

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| **Model name** | **General description** | **Details** |
| LRE Baseline (2015) | The ‘reset’ farm configuration i.e. without Africa RISING technologies or techniques in 2015. | 1.56 ha: Maize (1.54), AR maize (15X15m), cassava (15x15m)  No livestock; 9 household members    *Decision-variables for the exploration (ha): Maize (min:0, max:3).* |
| LRE Baseline - Drought | The baseline farm configuration under impact of a severe drought | Yield loss:  Local maize -70%  Cassava: -35%  Subsequent changes in crop prices:  Maize +50%  Cassava: +60%  Labour: Overall: -60% of the labour (less weeding, less harvesting) |
| LRE Exploration – Recovery options for the year after the drought year (without AR) | Exploration of alternative farm configurations as recovery options from drought for the farm WITHOUT novel crops or cultivation technologies/techniques | Starting point for the exploration (search of options for the next years’ growing season) is ~April of the subsequent year: Maize: smaller area (1ha), due to financial constraints for inputs. Remainder: fallow. Max. 1.2 ha of maize; Cassava: same area as baseline year and ‘normal’ yield, since no need for inputs.  *Modelling note: drought maize or cassava are not available for the model during the exploration.* |
| LRE Exploration – Recovery options for the year after the drought year (with AR) | Exploration of alternative farm configurations as recovery options from drought for the farm WITH technology package P1, since the other packages were deemed unsuitable for the LRE farm household. | Same as above + P1: min. area, min. 0 ha, max. 1.2 ha. |
| LRE Baseline – Price Shock | The baseline farm configuration under impact of a severe price shock | Market prices drop:  Maize: -50%  Cassava: -20% |
| LRE Exploration – Recovery options for the year after the price shock-year (without AR) | Exploration of alternative farm configurations as recovery options from the price shock for the farm WITHOUT novel crops or cultivation technologies/techniques | Starting point for the exploration (search of options for the next years’ growing season) is ~April of the subsequent year: Maize: smaller area (1ha), due to financial constraints for inputs. Max. 1.3 ha of maize. Max. total area the same (1.56 ha); Cassava: same area as baseline year and normal yield, since no need for inputs.  Modelling note: Prices are back to the normal level. |
| LRE Exploration – Recovery options for the year after the price shock-year (with AR) | Exploration of alternative farm configurations as recovery options from the price shock for the farm WITH technology package P1, since the other packages were deemed unsuitable for the LRE farm household. | Same as above + P1: min. area, min. 0 ha, max. 1.3 ha for maize. |

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| **Model name** | **General description** | **Details** |
| MRE Baseline (2015) | The ‘reset’ farm configuration i.e. without Africa RISING technologies or techniques in 2015. | Total farm size 10.3 ha: maize, HHH (1.94), rice, son\_36 (1.82), cowpea son\_20 (0.405), yam, HHH (0.405), fallow (2.835), soybean, HHH (1.21), soybean, son\_36 (0.6075), cowpea, son\_22 (0.405), cowpea, son\_29 (0.6075)    Livestock: 10 ducks, 4 chicken, 4 goats and 5 sheep    *Decision-variables for the exploration (ha): Maize (min:0, max:4), Rice, son\_36 (fixed), Cowpea\_son\_20 (min: 0-0.61), yam (fixed), fallow (0-6), soybean, HHH (0-1.8), soybean, son\_36 (0-1), cowpea, son\_22 (0-0.61), cowpea, son\_29 (0-1), Goats (4-6 animals)*  *Sheep (5-7 animals), use of own crop residues for feed.* |
| MRE Baseline - Drought | The baseline farm configuration under impact of a severe drought | Maize (yield: -80%, price: +50%), soybean (y:-85%, p:+30%), yam (y:-35%, p:+45%), cowpea (y:-80%, p:+30%) and rice (y:-60%,p:+30%). Labour: -60%. Sold: 2 sheep and 1 goat (+530 GHS extra income),  +50% import of external grazing grass as well as maize bran for ruminants and a +10% higher import of (second quality) maize grain as poultry feed, to compensate for lower on-farm residue availability |
| MRE Exploration – Recovery options for the year after the drought year (without AR) | Exploration of alternative farm configurations as recovery options from drought for the farm WITHOUT novel crops or cultivation technologies/techniques | Starting point for the exploration (search of options for the next years’ growing season) is ~April of the subsequent year: the household still has the same number of goats and sheep as after the shock; the household can only plan smaller field sizes, especially for chemical input intensive crops:  maize, HHH (1.94, same area = food sec., min:0,max: 2.5), rice, son\_36 (1,fixed), cowpea son\_20 (0.2025, min:0, max: 0.405), yam, HHH (0.405, no inputs needed, fixed), fallow (5.631, min:0, max: 6), soybean, HHH (0, min:0, max: 1.25), soybean, son\_36 (0.2025, min:0, max: 0.7), cowpea, son\_22 (0.2025, min:0, max: 0.405), cowpea, son\_29 (0.2025, min:0, max: 0.6075). Hence we assume that both, the HHHs fields and the fields of his sons are affected and will be smaller. To balance the feed, changes in imported feed: for small ruminants - 30% grazing grass, -33% maize bran, -100% pigeon pea husks and – 63% cassava peels, for poultry: +5.2% in maize grains (second quality). Goats/sheep (min:3, max:5 animals of each type) |
| MRE Exploration – Recovery options for the year after the drought year (with AR) | Exploration of alternative farm configurations as recovery options from drought for the farm WITH technology packages P1, P2, P4, P6 and P7 – the packages that are suitable and affordable for this household | Same as above + P1, P2, P3, P4, P6 (min. areas: min. 0 ha, max: as above), P6 (groundnuts) can be chosen instead of cowpea or groundnuts. Max. two P7-goats and two P7-sheep allowed (only imported feed allowed: free external grazing grass and the concentrate feed) |
| MRE Baseline – Price Shock | The baseline farm configuration under impact of a severe price shock | Due to the improved storage and ability to sell livestock before selling the grains, the MRE is assumed to be able to buffer the price shock to some degree. Price drops:  Maize: -30%  Rice: -10%  Yam:-10% |
| MRE Exploration – Recovery options for the year after the price shock-year (without AR) | Exploration of alternative farm configurations as recovery options from the price shock for the farm WITHOUT novel crops or cultivation technologies/techniques | Starting point for the exploration (search of options for the next years’ growing season) is ~April of the subsequent year: Maize: same area, but smaller max. areas for crops during the exploration, due to financial constraints: maize, HHH (min: 0, max: 3.75 ha), cowpea son\_20 (min: 0, max: 0.6), yam, HHH (0.405, no inputs needed, fixed), fallow (min:0, max: 6), soybean, HHH (min:0, max: 1.7), soybean, son\_36 (min. 0, max: 0.8), cowpea, son\_22 (min. 0, max: 0.6), cowpea, son\_29 (min. 0, max. 0.9). Goats: 3 (min:3-max:5), sheep:5 (min:5-max:7). Less animal feed needed (grazing grass: -50%, cassava peels: -28%) |
| MRE Exploration – Recovery options for the year after the price shock-year (with AR) | Exploration of alternative farm configurations as recovery options from the price shock for the farm WITH technology packages P1, P2, P4, P6 and P7 – the packages that are suitable and affordable for this household | Same as above + P1, P2, P3, P4, P6 (min. areas: 0 ha, max as above), P6 (groundnuts) can be chosen instead of cowpea or groundnuts. P7: two P7-goats and two P7-sheeps allowed (only imported feed allowed: free external grazing grass and the concentrate feed). |

|  |  |  |
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| **Model name** | **General description** | **Details** |
| HRE Baseline (2015) | The ‘reset’ farm configuration i.e. without Africa RISING technologies or techniques in 2015. | Total field size (28.4 ha): maize, HHH (6.89), groundnut, wife (0.405), rice, son\_S. (12.15), yam + maize, HHH (0.405), soybean + sorghum, HHH (0.405), maize, compound field (0.405), tomato + pepper (0.0075), maize + cassava, HHH (0.405), soybean, son\_S. (4.86), maize, son\_A. (2.025), rice, son\_A. (0.405)    Livestock: 6 broiler chicken, 15 guinea fowl, 19 improved bulls, 14 layer chicken, 4 local bulls, 10 local cows, 4 local goats, 6 local heifers, 15 sheep    *Decision-variables for the exploration: 28.4 ha (min:4, max:20 ha), yam + maize, HHH (6.89, min:0, max: 2), groundnut, wife (0.405, min: 0, –max: 0.5), rice, son\_S. (12.15, fixed), yam + maize, HHH (0.405, min:0, max:2), soybean + sorghum, HHH (0.405, min:0, max: 2), maize, compound field (0.405, min:0, max:0.5), tomato + pepper (0.0075, fixed), maize + cassava, HHH (0.405, min:0, max:2), soybean, son\_S. (4.86, min:2, max:6), maize, son\_A. (2.025, min:1, max:4), rice, son\_A. (0.405, fixed)* |
| HRE Baseline - Drought | The baseline farm configuration under impact of a severe drought | Maize (yield: -80%, price: +50%), millet/sorghum (y:-65%, p:+150%), soybean (y:-85%, p:+30%), yam (y:-35%, p:+45%), cowpea (y:-80%, p:+30%), rice (y:60%,p:+30%) and groundnuts (y: -30%, p:+30%). Labour: -60%. Sold: 3 bulls (3000GHS) and 5 guinea fowls (125 GHS), increase in imported animal feed (+184% in cassava peel for ruminants; and -17% in maize grain and – 20% in cowpea residues for poultry) to compensate for lower on-farm residue availability |
| HRE Exploration – Recovery options for the year after the drought year (without AR) | Exploration of alternative farm configurations as recovery options from drought for the farm WITHOUT novel crops or cultivation technologies/techniques | Starting point for the exploration (search of options for the next years’ growing season) is ~April of the subsequent year: farmer still has the same number of cattle and guinea fowl as after the shock; the household cultivates the same field sizes, but the different farmers (household members) have a smaller room to manoeuvre. Total area: 28.4 ha (min: 10, max: 30): maize, HHH (min: 4, max:10), groundnut, wife (min: 0.2025, max: 0.5), rice, son\_S. (12.15, fixed), yam + maize, HHH (min: 0, max: 1), soybean + sorghum, HHH (min:0, max:1), maize, compound field (min:0, max:0.5), tomato + pepper (0.0075, fixed), maize + cassava, HHH (min: 0, max: 1), soybean, son\_S. (min: 2, max:5), maize, son\_A. (min:1, max:3), rice, son\_A. (0.405, fixed). Reduction in feed requirements:-100% in cassava peels and – 6.5% in grazing grass for ruminants and -17% in maize grain and – 20% in cowpea residues for poultry. Goats (min:2, max:8), sheep (min:8, max:20) |
| HRE Exploration – Recovery options for the year after the drought year (with AR) | Exploration of alternative farm configurations as recovery options from drought for the farm WITH technology packages P1, P2, P4, P6 and P7 – the packages that are suitable and affordable for this household | Same as above + P1, P2, P3, P4, P6 (min. area, 0.2025ha, max as above), P6 (groundnuts) can be chosen instead of soybean or groundnuts. max. five P7-goats and ten P7-sheep allowed (only imported feed allowed: free external grazing grass and the concentrate feed) |
| HRE Baseline – Price Shock | The baseline farm configuration under impact of a severe price shock | The HRE farm is not selling crops during the price shock, but rather buying and selling some grains to generate an extra profit. We hence assumed ‘normal crop prices’ and an extra income of 250 GHS in the drought year (assuming the purchase and re-sale of five maize bags, earning 50 GHS of profit each). |
| HRE Exploration – Recovery options for the year after the price shock-year (without AR) | Exploration of alternative farm configurations as recovery options from the price shock for the farm WITHOUT novel crops or cultivation technologies/techniques | Starting point for the exploration (search of options for the next years’ growing season) is ~April of the subsequent year: the farmer indicated that this household would benefit from a price shock, since it would buy grain when the seasonal price is low, eat as much as they need and then sell it again when the prices are better and the household. We hence provided the model with a greater room to manoeuvre as compared to the baseline: total area: 28.4 ha (min: 10, max: 55): maize, HHH (6.89, min: 4, max:24), groundnut, wife (0.405, min: 0, max: 2.5), rice, son\_S. (12.15, fixed), yam + maize, HHH (0.405, min: 0, max: 2.5), soybean + sorghum, HHH (0.405, min:0.2025, max:2.5), maize, compound field (0.405, min:0, max:0.5), tomato + pepper (0.0075, fixed), maize + cassava, HHH (0.405 min: 0, max: 2.5), soybean, son\_S. (4.86, min: 2, max:8), maize, son\_A. (2.025, min:1, max:6), rice, son\_A. (0.405, fixed). Goats (min:2, max:12), sheep (min:8, max:25) |
| HRE Exploration – Recovery options for the year after the price shock-year (with AR) | Exploration of alternative farm configurations as recovery options from the price shock for the farm WITH technology packages P1, P2, P4, P6 and P7 – the packages that are suitable and affordable for this household | Same as above + P1, P2, P3, P4, P6 (min. area, 0 ha, max as above), P6 (groundnuts) can be chosen instead of soybean or groundnuts. max. 10 P7-goats and 15 P7-sheep allowed (only imported feed allowed: free external grazing grass and the concentrate feed) |

The constraint that a crop area should be at least 0.2025 ha as used in Michalscheck (2019; 2020, in prep.) has been ignored in this research project to be able to see also what small changes in areas impact nutrition.

**2b. Modelling the Africa RISING practices**

From Michalscheck et al. (2018; 2020, in prep.)

P1: improved maize seeds (21 kg/ha) planted in rows, fertiliser application (247 kg/ha NPK and SA = tot. 90 kg of N/ha)

*Costs for improved seeds are 3.3 GHS/kg. Need 21 kg/ha.  
 Average additional labour is 2.5 h/ha.  
 Assumed yield increase: 25%*

P2: improved cowpea seeds (20 kg/ha) planted in rows, sprayed three times (Lambda cyhalothrin (2.5%)

*Costs for improved seeds are 6.7 GHS/kg. Need 20 kg/ha.  
 Average additional labour is 2.5 h/ha for harvesting and 1.25 h/ha per spray.  
 Assumed yield increase: 45%*

P3: improved soybean seeds (37 kg/ha), fertiliser (TSP: 123 kg/ha), inoculant

*TSP costs 2.5 GHS/kg. Need 123 kg/ha. Inoculum costs 200 GS/kg. Need 0.247 kg/ha.  
 Costs for improved seeds are 4.6 GHS/kg. Need 37 kg/ha.  
 Average additional labour: 18 h/ha.  
 Assumed yield increase: 50%*

P4: rotation with maize (2/3) and cowpea or soybean (1/3)

*Average additional labour is 2.5 h/ha for maize, 5 h/ha for cowpea and 1.25 h/ha for soybean.  
 Assumed yield increase is 50% for maize.*

P5: strip crop with maize (2 rows) and legume (2 rows) with rotating strips from one year to another

*Average additional labour is 3.7 h/ha for maize, 7.4 h/ha for cowpea and 1.85 h/ha for soybean.  
 Assumed yield increase is 50% for maize.*

P6: improved groundnut seeds (37 kg/ha), spacing: 30x15 cm

*Costs for improved seeds are 6 GHS/kg. Need 37 kg/ha.  
 Average additional labour: 10%  
 Assumed yield increase: 80%*

P7: feed and health intervention for goats and sheep, concentrate feed, vaccination (PPR), deworming

*For female adult sheep or goats to improve their health, growth and reproduction rate.  
Costs for vaccination: 2 GHS/animal/year  
Costs for deworming: 6 GHS/animal/year  
Costs for concentrate feed: 30 GHS/animal/year  
Average weight gain: 15%*

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